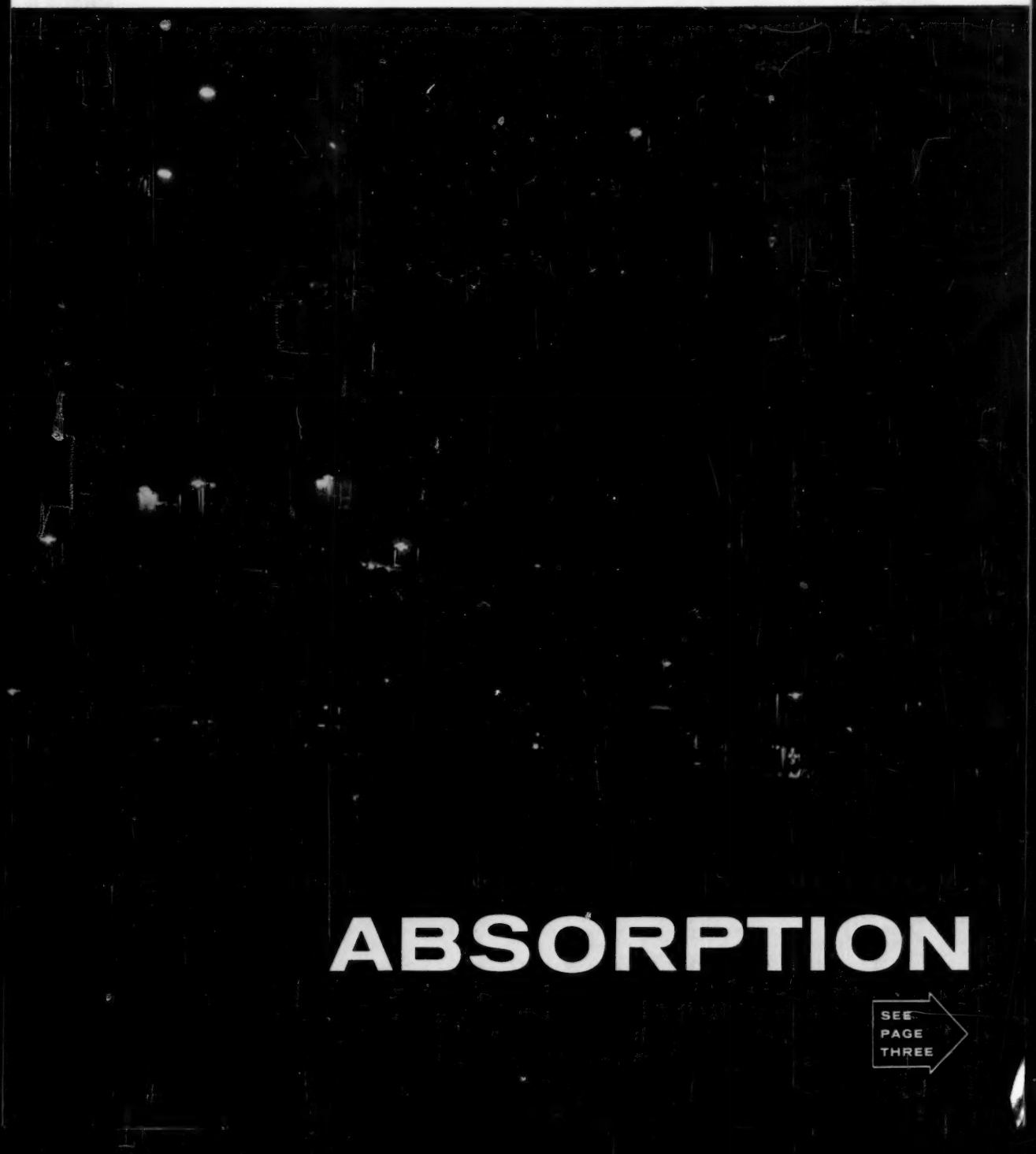
JULY 11, 1960
Published every-other-Monday
Seventy-five cents

Chemical Engineering

A McGRAW-HILL PUBLICATION



ABSORPTION

SEE PAGE THREE

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You save valuable time when you buy Epon resin solutions, because weighing, compounding, filtering, and standardizing are done for you right at the Shell Chemical plant.

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Epon 834-X-90	834	Xylene	90
Epon 836-C-75	836	MIBK	75
Epon 1001-A-80	1001	Acetone	80
Epon 1001-B-80	1001	MEK	80
Epon 1001-BT-70	1001	MEK/Toluene (50/50)	70
Epon 1001-CX-75	1001	MIBK/Xylene (65/35)	75
Epon 1001-T-75	1001	Toluene	75
Epon 1001-X-75	1001	Xylene	75
Epon 1007-CT-55	1007	MIBK/Toluene (50/50)	55

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SHELL

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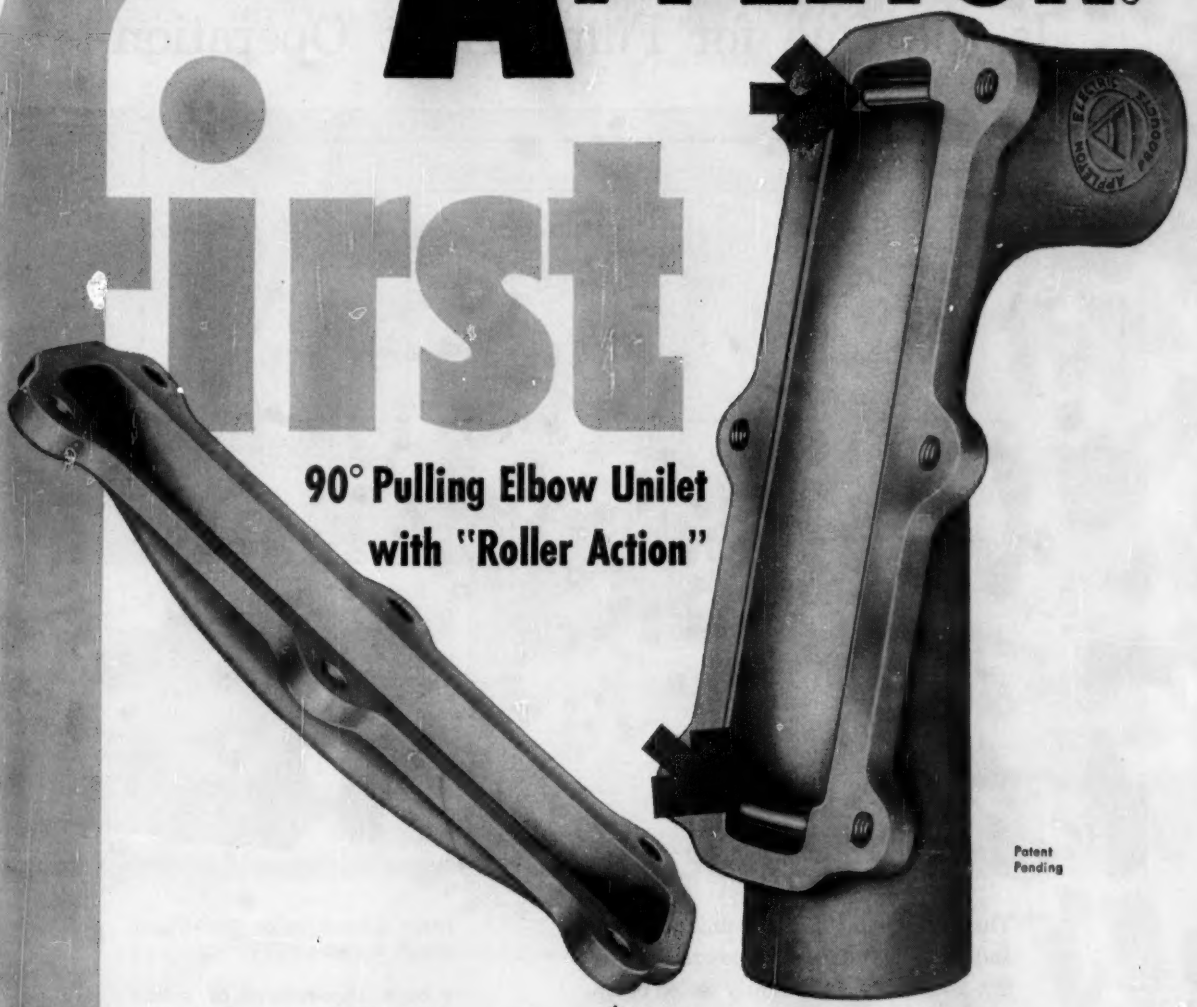
90° Pulling Elbow Unilet with "Roller Action"



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It's a time and cost saver for your more difficult wiring installations in hazardous locations. Large cables literally "roll through" the Appleton ELBD Unilet to give you faster, easier, lead-in wiring for motors, panel boards, circuit breakers and similar equipment.

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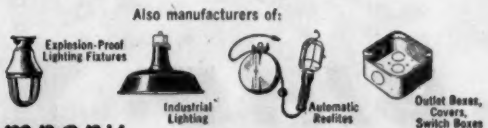
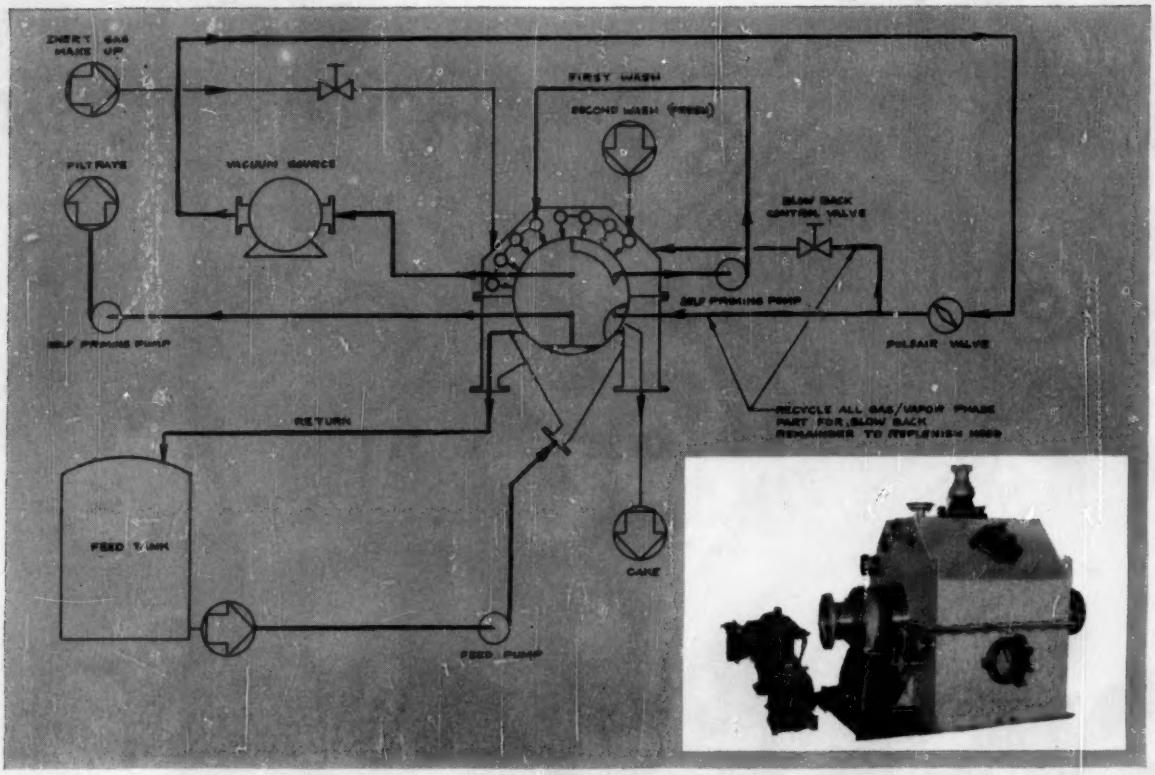


*Class 1, Group D; Class 2, Groups E, F, G

1701 Wellington Avenue, Chicago 13, Illinois

One Look at this Flow Sheet Tells You That the BIRD-YOUNG Vacuum Filter Is the One for Fume-Tight Operation



The Bird-Young Filter's unique design and simplicity of construction readily permit totally enclosed, tightly sealed operation. Exhausted air or vapor is subject to return so that pressure is always balanced and loss or expensive recovery of volatile solvents is avoided.

Before you buy a vacuum filter, look into the Bird-Young. The Bird Research and Development Center is well equipped to give you a look at actual performance facts and figures in advance of your investment.

Other advantages of Bird-Young design include:

- **high throughput of solids per foot of filter area** which often means fewer or smaller units
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July 11, 1960 **Chemical Engineering** Vol. 67, No. 14

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Under severe conditions, "Buffalo" Class "RR" Multi-Stage Pumps can't be beat. The "RR" is mechanically right, hydraulically efficient. It is designed to achieve near perfect hydraulic balance. Result: peak efficiency which delivers more water at less expense for power.

These rugged "Buffalo" Pumps stand up under prolonged continuous service. Maintenance is at a minimum. Performance is head and shoulders above ordinary pumps.

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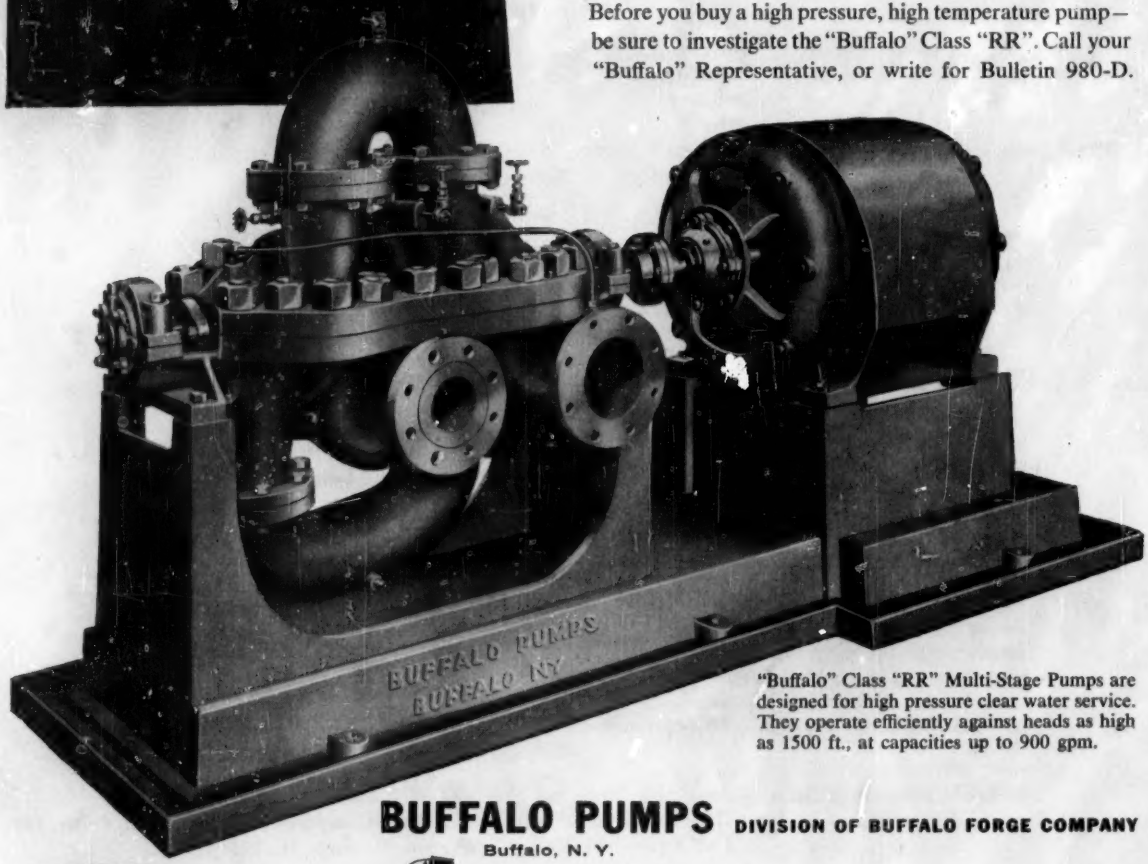
Before you buy a high pressure, high temperature pump—be sure to investigate the "Buffalo" Class "RR". Call your "Buffalo" Representative, or write for Bulletin 980-D.



"Buffalo" Class "RR" Multi-Stage Pumps are designed for high pressure clear water service. They operate efficiently against heads as high as 1500 ft., at capacities up to 900 gpm.

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Buffalo, N. Y.

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Buffalo air handling equipment to move, heat, cool, dehumidify and clean air and other gases.

Buffalo Machine Tools to drill, punch, shear, bend, slit, notch and cope for production or plant maintenance.

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Chemical Engineering (with Chemical & Metallurgical Engineering) is published biweekly by McGraw-Hill Publishing Company, Inc., James H. McGraw (1860-1948), Founder.

Publication Office: 99-129 North Broadway, Albany 1, N. Y.

Executive, Editorial, Circulation and Advertising Offices, 330 West 42nd St., New York 36, N. Y. **Officers of the Publications Division:** Nelson L. Bond, President; Shelton Fisher, Wallace F. Traendly, Senior Vice Presidents; John R. Callaham, Vice President and Editorial Director; Joseph H. Allen, Vice President and Director of Advertising Sales; A. R. Venezian, Vice President and Circulation Coordinator. **Officers of the Corporation:** Donald C. McGraw, President; Joseph A. Gerardi, Hugh J. Kelly, Harry L. Waddell, Executive Vice Presidents; L. Keith Goodrich, Vice President and Treasurer; John J. Cooke, Secretary.

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Second class postage paid at Albany, N. Y. Printed in U.S.A. Title registered in U.S. Patent Office.

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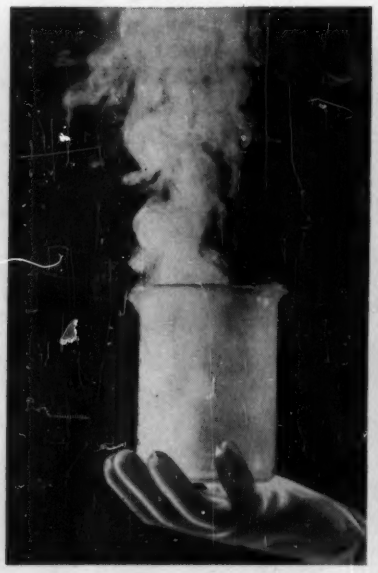

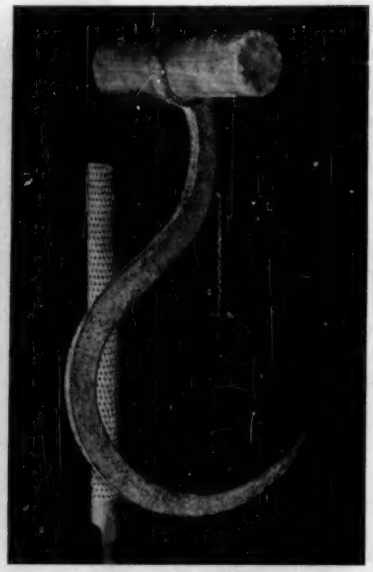

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Enjay Butyl offers the highest aged tear strength of any rubber . . . even after long exposure to ozone and heat! Its inherent toughness resists abrasive wear, in such applications as tires, conveyer belts, hose and other mechanical goods.

RESISTANCE TO SUN-LIGHT AND WEATHERING

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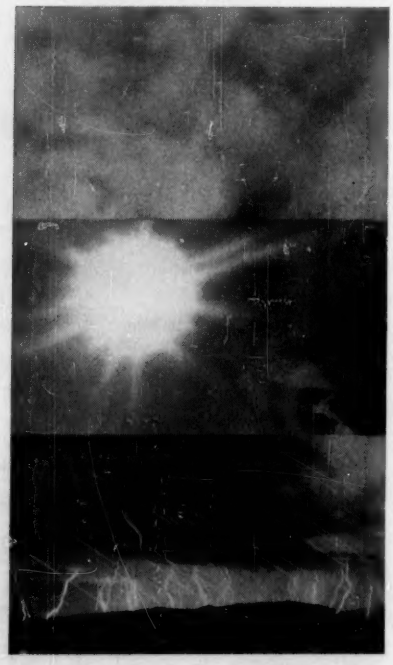
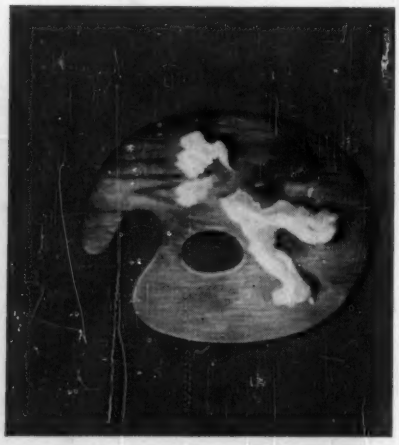
RESISTANCE TO CHEMICALS

Enjay Butyl, because of its unique and extremely low degree of unsaturation, offers excellent resistance to corrosive chemicals. The preferred rubber for tank linings, hose, seals, gaskets and other applications where exacting chemical resistance is required.





VIVID COLORS

Enjay Butyl requires no additives for quality coloring over a wide range of hues. Famous for colorability and smooth finishes, Butyl has been successfully plastic coated for special applications.

RUBBER

PERFORMANCE

DAMPING PROPERTIES

Enjay Butyl absorbs shock and vibrational energy more completely than any other rubber. Resiliency can be varied in compounding and processing. Butyl is ideal for axle and body bumpers, motor mounts and sound-deadening applications.

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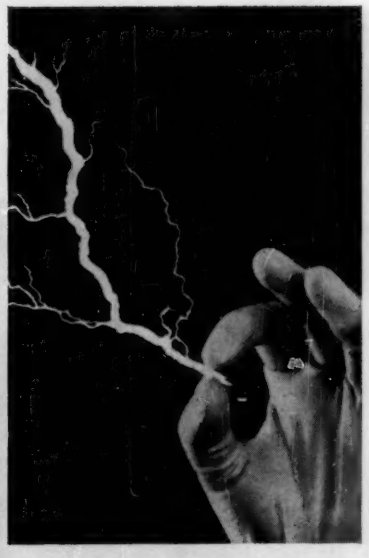
Enjay Butyl is tops in impermeability to gases and moisture . . . retains air pressure 8 times better than natural rubber. Outperforms other rubbers in such application as inner tubes, jar and bottle seals, hoses and inflatable goods.



ELECTRICAL RESISTANCE

Enjay Butyl tops all vulcanizable rubbers in electrical and dielectric properties . . . in resistance to corona and ozone breakdown and water absorption. Its high dielectric strength insures against electric breakdown under normal or surge voltage. Its heat resistance permits higher current flow for a given conductor size.

The outstanding properties of Butyl Rubber create new horizons for the designer, and offer to manufacturers an opportunity to utilize the qualities of rubber in applications never before possible. The unique properties of Butyl have led to vast improvement in many existing products. Technical skills will open the way to countless new uses.

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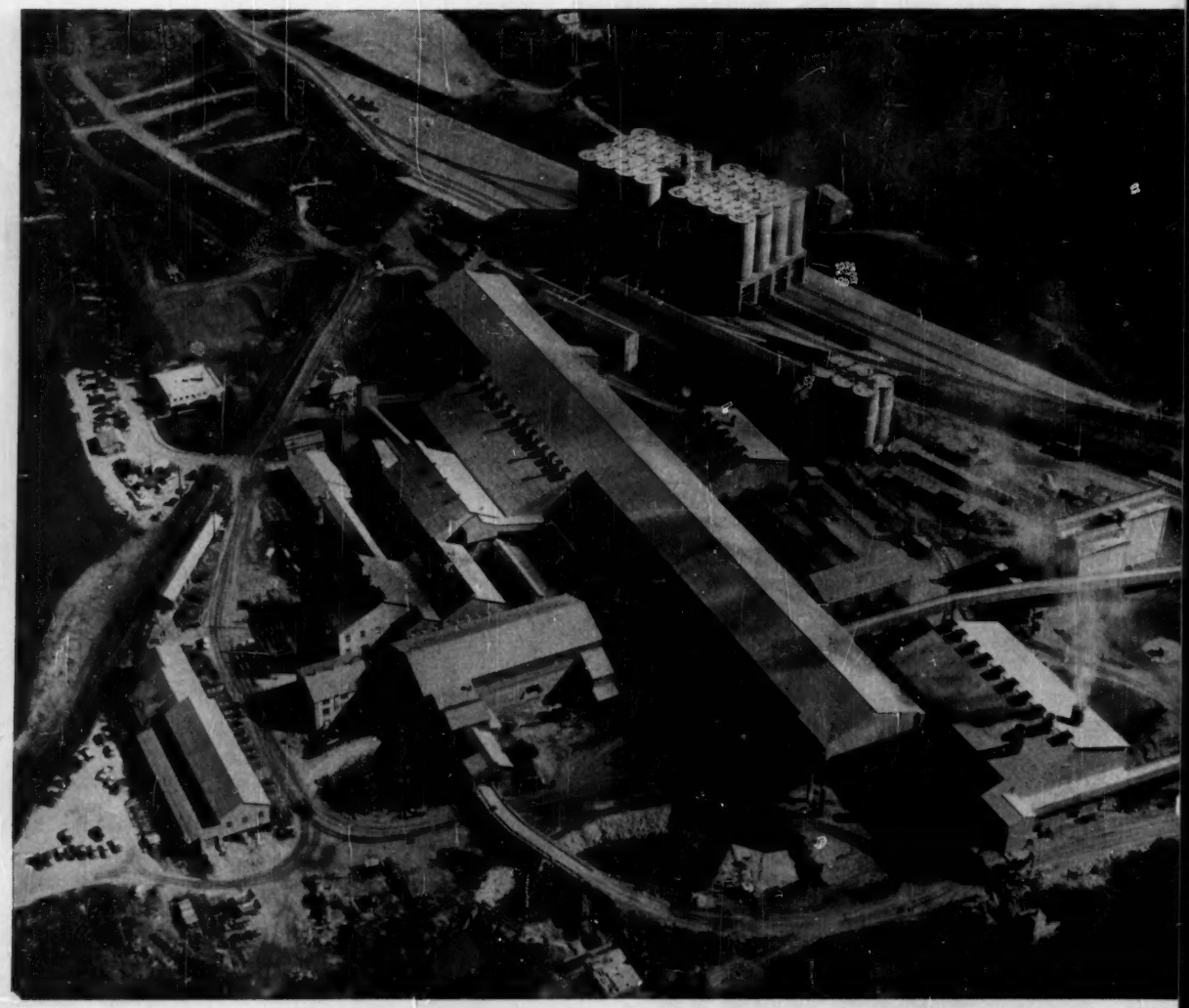

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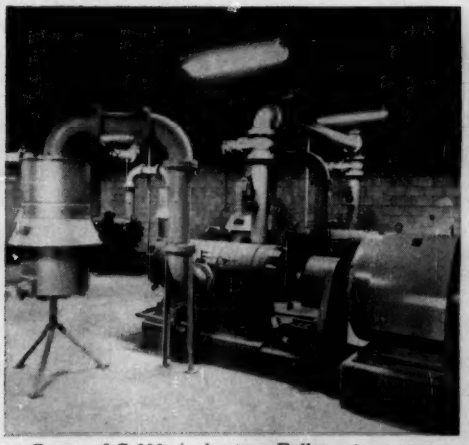
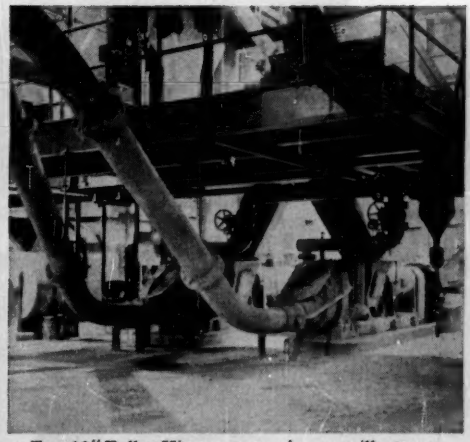
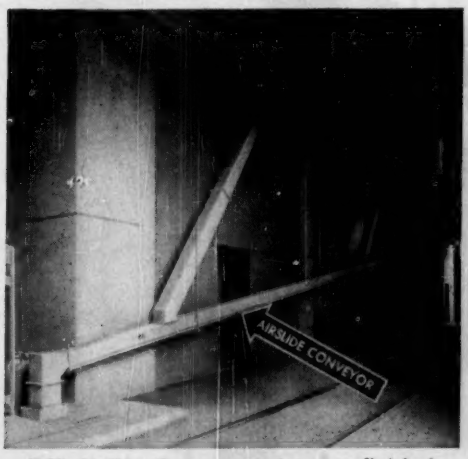


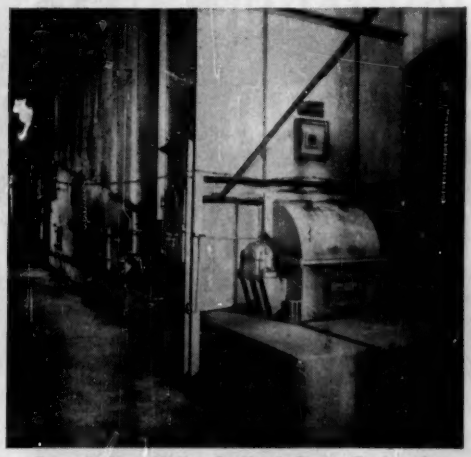
Group of C-300 single stage Fuller rotary compressors furnishing air for the Fuller-Kinyon pumps in raw-finish department.



Two 10″ Fuller-Kinyon pumps in raw mill pumping material to blending silos.



F-H Airslide Conveyor under new finished cement silos feeding to Fuller-Kinyon pump for redistribution.



One of three Fuller Inclined Grate Coolers in kiln building.

Automation with a variety of Fuller equipment at Lehigh Portland Cement Company's Union Bridge, Maryland plant has helped triple capacity from 1,000,000 to 3,000,000 barrels a year.

In this installation, Fuller-Kinyon pumps handle both cement raw material and finished cement to and from process.

Fuller rotary compressors furnish air for both the Fuller-Kinyon pumps and general plant air.

Airslide® Fluidizing Conveyors are used at various stages of both the raw and finished mill operations in feeding both raw material and finished cement to and from process and storage.

Clinker is discharged from three 400′ kilns and cooled to about 145°F. by three Fuller 7′ x 44′ Inclined Grate Coolers.

This wide range of Fuller systems and equipment in the field of pneumatic handling makes it possible for Fuller to find the method of moving dry bulk granular materials best suited to your particular application. Why not write for complete details today? 1324 G-198-T

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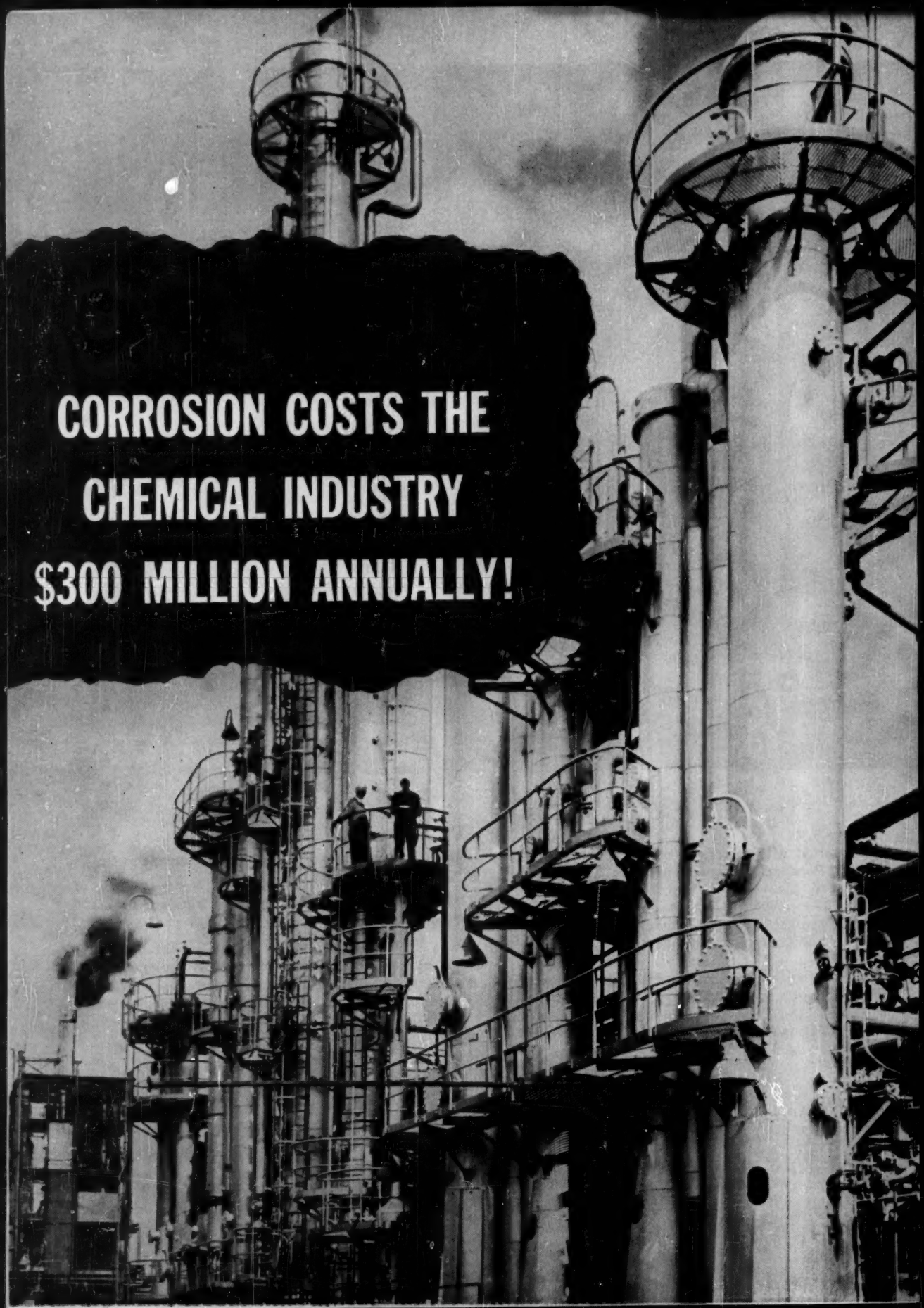
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CHEMICAL INDUSTRY
$300 MILLION ANNUALLY!

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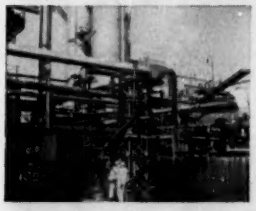
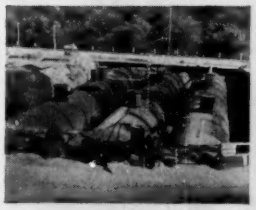


The original, patented coal tar-epoxy coating, Tarset is now solving many of the severest corrosion problems in the chemical industry. Years of service as lining for acid and alkali tanks, and on piping and structural steel, have proven the revolutionary ability of Tarset to withstand extreme chemical corrosion.

PITT CHEM TARMASTIC®



PITT CHEM Tarmastic coal tar coatings are a series of thick-film protective coatings designed to solve a wide variety of corrosion problems at moderate cost. Excellent for protection of hoods, fans, housing and other equipment against steam and very corrosive vapors, mild acid and alkaline solutions and extreme moisture conditions.

PITT CHEM INSUL-MASTIC®

Vapor and moisture penetration problems are solved economically and effectively with time-tested Insul-Mastic Gilsonite-asphalt coatings. Ideal for the protection of metal, concrete and masonry surfaces against weather, moisture and many chemicals and vapors. Insul-Mastic cork mastics provide good insulating qualities and condensation control.

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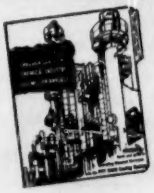

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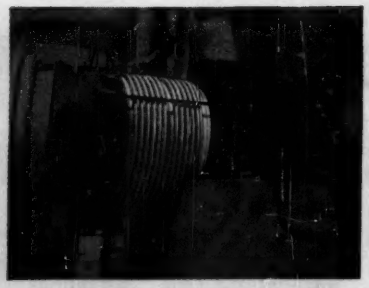
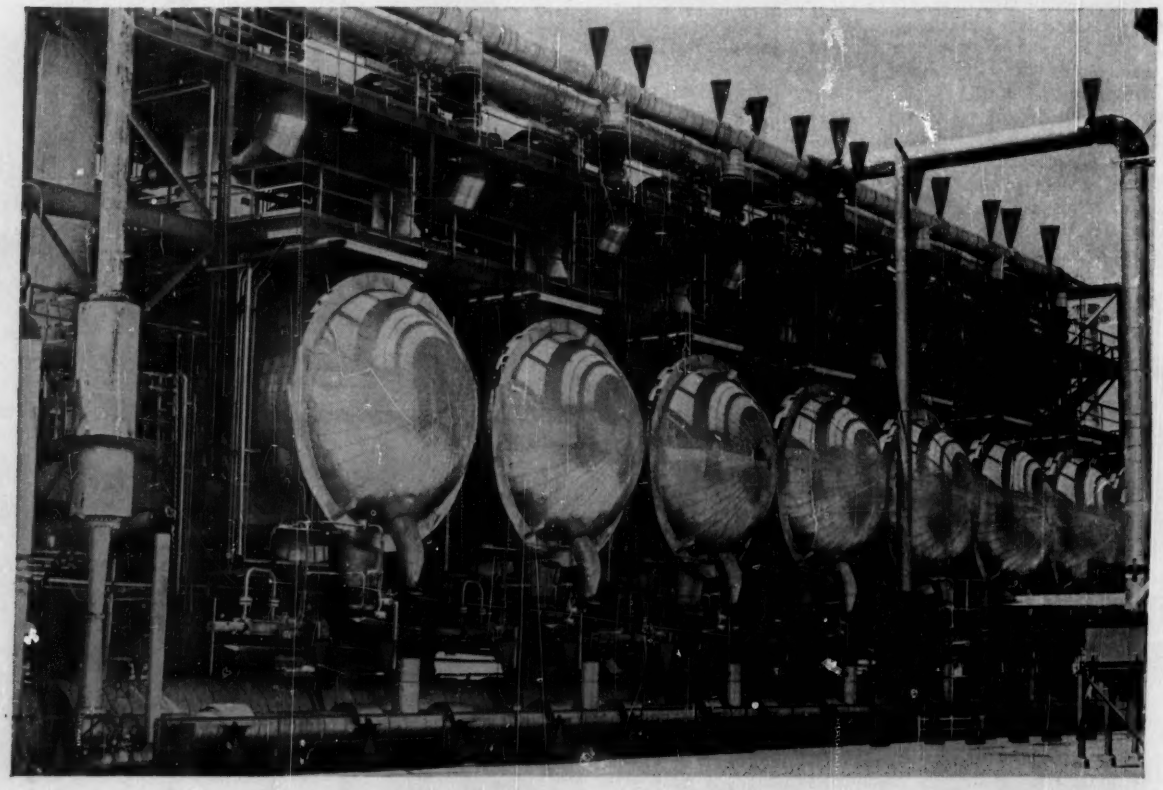
1136

85½ in. dia. expansion joint connecting quench and pre-quench towers. Pinned structural ties permit expansion joint to absorb axial and differential vertical movement.



48 in. dia. expansion joint at compressor discharge. Double bellows permit large axial movement. Internal sleeve guide provides for stability, minimum pressure drop.

54 in. dia. hinged expansion joints in loop to pre-quench tower. They absorb 5⅜ in. vertical expansion and 7⅜ in. horizontal expansion due to 1200°F temperature in reactor header.



125 ZALLEA EXPANSION JOINTS, 125 demands for maximum reliability

Expansion joints, specially engineered and designed by Zallea, solve problems of space, heat and flow for Odessa Butadiene Co., Odessa, Texas.

Large-diameter piping (up to 72 in. dia.), with short, straight runs and critical flow conditions, posed new design problems. High temperature operation (1200°F) required minimum loading on sensitive equipment. Open-air construction, with few load carrying members dictated maximum stability of expansion joints with minimum use of external guides and anchors to support pipe weight and resist wind loading.

To solve these problems called for a competent, close-working team of process, piping and structural engineers from Fluor Corp. Ltd., design engineers from Odessa Butadiene Co., and application engineers from Zallea.

Result: A compact, reliable piping-expansion joint system that permitted containment of an efficient, 50,000 ton per year unit in an area whose largest dimension is a few hundred feet.

This is another example of how Zallea experience in handling critical, complex Expansion Joint applications can save time and money. For more facts, call us . . . or write for catalog 56.

ZALLEA BROTHERS, Taylor and Locust Sts., Wilmington 99, Del.

Zallea **FOR MAXIMUM RELIABILITY**

WORLD'S LARGEST MANUFACTURERS OF EXPANSION JOINTS

Safe-pouring space savers that stack up...

HACKNEY STAINLESS STEEL CHEMICAL CONTAINERS

Here are the chemical containers everybody likes—shippers, carriers, handlers, users! Lightweight, strong, leakproof and stackable, they protect your dangerous or corrosive products, eliminate accidental breakage, and safeguard handlers.

Hackney chemical containers are built of Types 304 and 316 stainless steel. Bottom foot ring fits snugly over the top ring of the barrel beneath to permit safe stacking. That means real savings in warehouse space and handling time. Full-curled top and bottom rings give handlers full gripping areas. Dropping and spilling are cut to a minimum. And for further safety, a splashproof pouring spout is available as an optional accessory.

Hackney chemical containers hold approximately 15½ gallons of liquid. Size: approximately 17⅝" x 22⅛". Owner's name can be embossed in foot ring. For more details, write to the address below.

Pressed Steel Tank Company

Manufacturer of Hackney Products

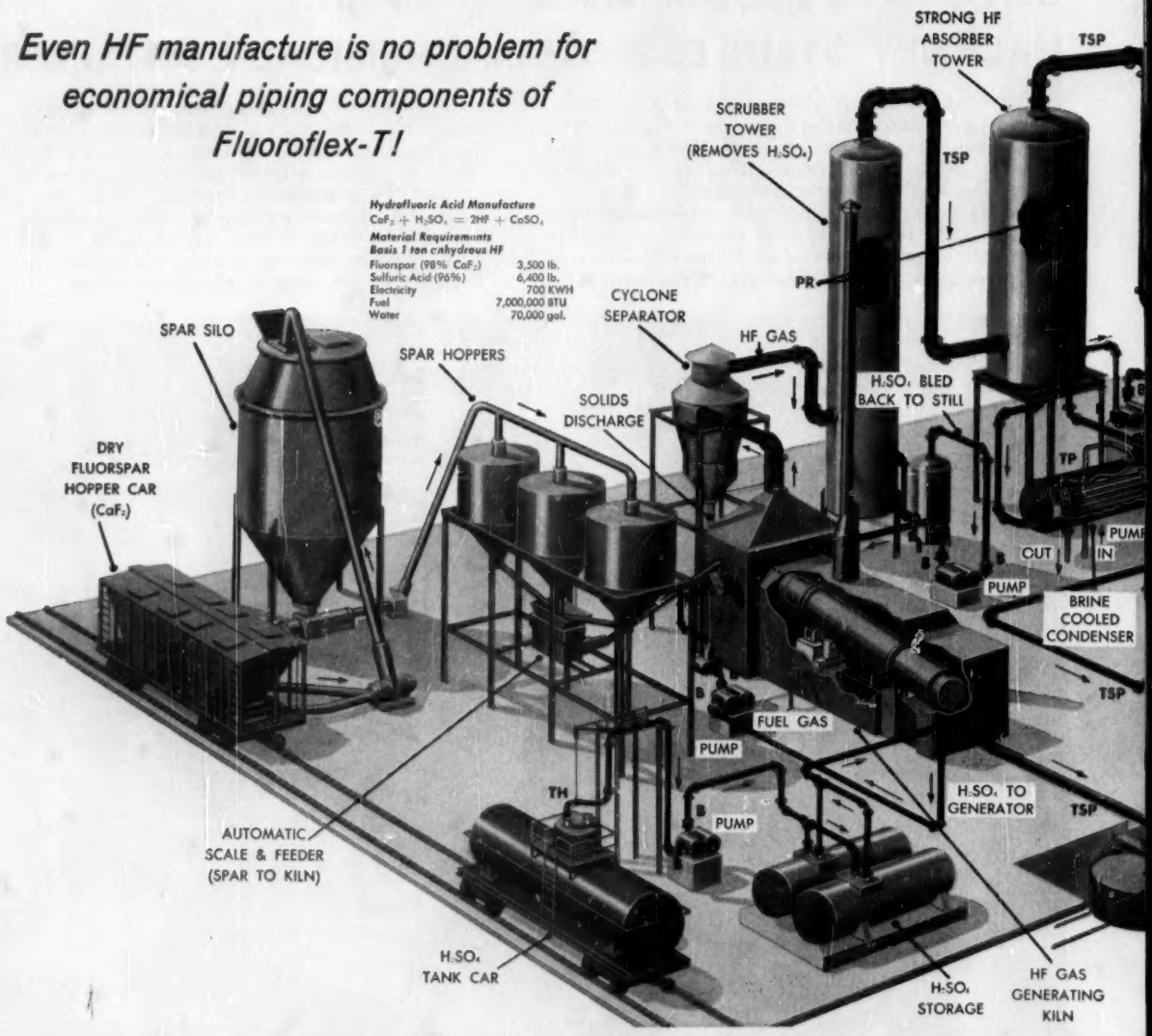
1447 South 66th Street, Milwaukee 14, Wisconsin

Branch offices in principal cities

CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

Hackney

Even HF manufacture is no problem for economical piping components of Fluoroflex-T!



Hydrofluoric Acid Manufacture
$CaF_2 + H_2SO_4 = 2HF + CaSO_4$

Material Requirements
Basis 1 ton anhydrous HF

Fluorspar (98% CaF_2)	3,500 lb.
Sulfuric Acid (96%)	6,400 lb.
Electricity	700 KWH
Fuel	7,000,000 BTU
Water	70,000 gal.

NOW AT LAST, for all your corrosive of long-life, corrosion-

Now it is possible for you to pipe your entire corrosive process from start to finish in corrosion-impervious Fluoroflex®-T, to save you money in faster installation, and decreased maintenance, process downtime, replacements, and production headaches!

Fluoroflex-T, the proprietary Teflon® product manufactured and fabricated solely by Resistoflex, combines two important elements:

1. The widely-known corrosion-imperviousness of Teflon; complete resistance to *any* chemical (except high-temperature fluorine and the molten alkali metals) up to 500°F.!

2. Optimum flexibility, density, strength, and flex-life; nonporosity and structural uniformity; all imparted by Resistoflex's superior fabrication techniques.

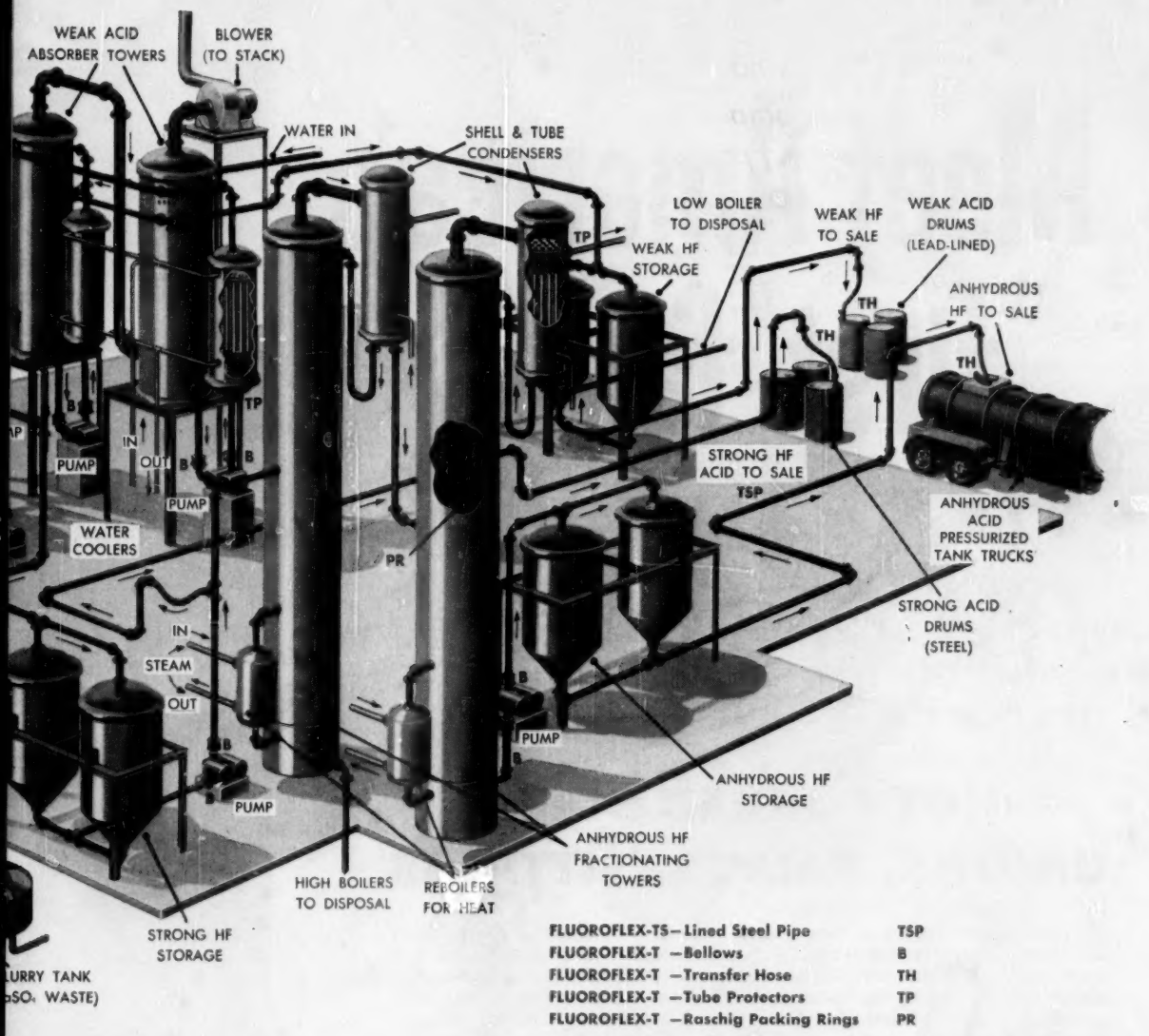
As to the kind of economies possible, one plant equipped with Fluoroflex-T reported savings of $60,000 per month in costs of maintenance, downtime, and product loss!

This in addition to installation economies. The Fluoroflex-T family of corrosion-resistant piping components (see panel at side) have all been designed for complete couplability and hookup ease, in a complete range of sizes to fit any flow, process, or process path.

If *you* have problems of handling corrosive fluids—in cost, equipment maintenance and replacement, process downtime—why not talk them over with Resistoflex? As they have for others, their fully experienced staff of engineers and equipment specialists may be able to save *you* money, time, and headaches! Write for Bulletin today!

Check These Versatile Fluoroflex-T Piping Components for Economy, Installation Ease, Long Process Life!

Fluoroflex-T Lined Steel Pipe: Prefabricated to section lengths, conforming to your blueprint specs, with flanges on and ready to assemble. Minimizes assembly time; shortens checkout time; suitable for all fluids; complete series of fittings and connections available.



FLUOROFLEX-TS—Lined Steel Pipe	**TSP**
FLUOROFLEX-T —Bellows	**B**
FLUOROFLEX-T —Transfer Hose	**TH**
FLUOROFLEX-T —Tube Protectors	**TP**
FLUOROFLEX-T —Raschig Packing Rings	**PR**

piping problems, the overall economy proof FLUOROFLEX-T (TEFLON)!

Chemical Transfer Hose: Completely resistant to corrosion; long flex life; available in rubber or stainless steel braid coverings. The answer to all your flex hose problems!

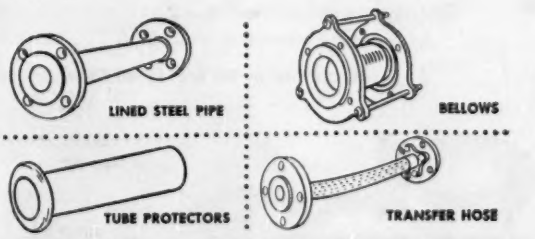
Molded Bellows-Flex Joints: Up to one million flexings without detectable deterioration! Adjust to longitudinal and temperature movements, damp out equipment vibrations. Molded rather than machined, their built-in flex-life can add years to the life of your piping and equipment!

Dip Pipes, Spargers, Thermowells: For non-corrosive nozzle openings, steam nozzles, instrument wells in process equipment.

Condenser Tube Protectors: Eliminate erosion and corrosion of high-velocity acid in entry side of condenser tubes.

And also:

Fluoroflex-T Tower Packing Rings: Light in weight, durable, corrosion and erosion resistant, these economical Raschig rings have only one-fourth the weight of monel rings! Next time you need tower packing, check on these to simplify your tower design, costs, maintenance problems!



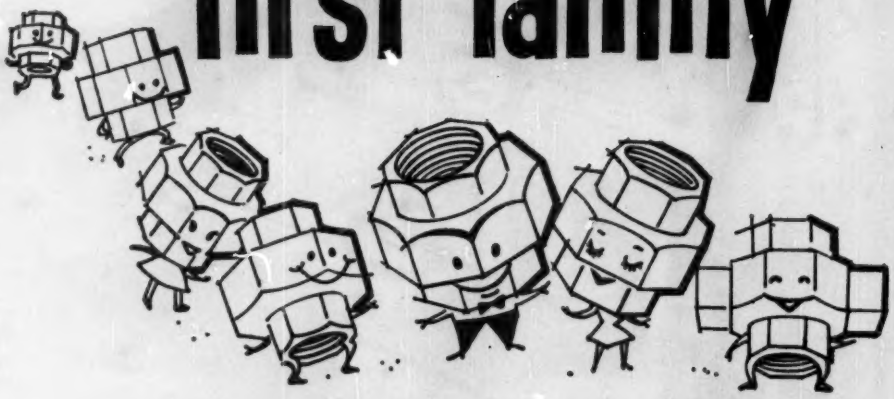
RESISTOFLEX CORPORATION

Complete systems for corrosive service

Plants in Roseland, N. J. • Anaheim, Calif. • Dallas, Tex. • *Sales Offices* in major cities

®Fluoroflex is a Resistoflex trademark, reg. U. S. Pat. Off.
®Teflon is DuPont's trademark for TFE fluorocarbon resins.

Meet America's "first" family



HOT FORGED STEEL UNIONS, VALVES & FITTINGS

No matter what the job or requirement . . . look to the Clayton Mark family of Unions, Valves and Fittings. With an "ancestry" that includes the *first* steel union in the industry, this illustrious family has many other accomplishments that command your attention. They were *first* to furnish the truly universal "Petro" Forged Steel Union to meet increasing pressure and temperature demands . . . *first* to introduce the fast-acting "Handlebar" type . . . *first* with Forged Stainless Steel Unions and *first* to produce a hardness differential in the seat to prevent galling. When you stock these members of the Clayton Mark family, you are assured of greater flexibility, less inventory and top performance.

Specify the brand that has been the "yardstick" of engineering acceptance since 1888 . . . **CLAYTON MARK**

Available in 50 States and throughout the world

CLAYTON MARK

AND COMPANY

1908 DEMPSTER STREET · EVANSTON, ILLINOIS · U.S.A.

PUMPS · WATER WELL SUPPLIES · CONDUIT · UNIONS · TUBING

CLAYTON MARK FORGED CARBON STEEL UNIONS

★ Last Longer!
★ Work Better!
★ Cost Less!

RESIST WRENCH ABUSE!
Clayton Mark forged steel unions withstand excessive wrench abuse and repeated making and breaking long after other unions . . . forged or cast . . . have been discarded. They work better because they are hot forged and have superior features. So, they cost less . . . as much as five times less . . . than other brands.

HERE ARE THE SUPERIOR FEATURES THAT MAKE CLAYTON MARK UNIONS BETTER!

HOT-FORGED INDUCTION HEATED parts are stronger, have uniformly fine grain structure

CADMIUM-PLATED NUT for rust-proofing permanent lubrication

OCTAGON WRENCH FLATS ON NUT AND ENDS for surer grip in making and breaking

45° CONE-TO-BALL SEAT easy to make up tight

HARDNESS DIFFERENTIAL BETWEEN SEATS prevents galling, assures repeated make-up

TURBULENCE-FREE FIT ACROSS SEAT cuts down damage to seats

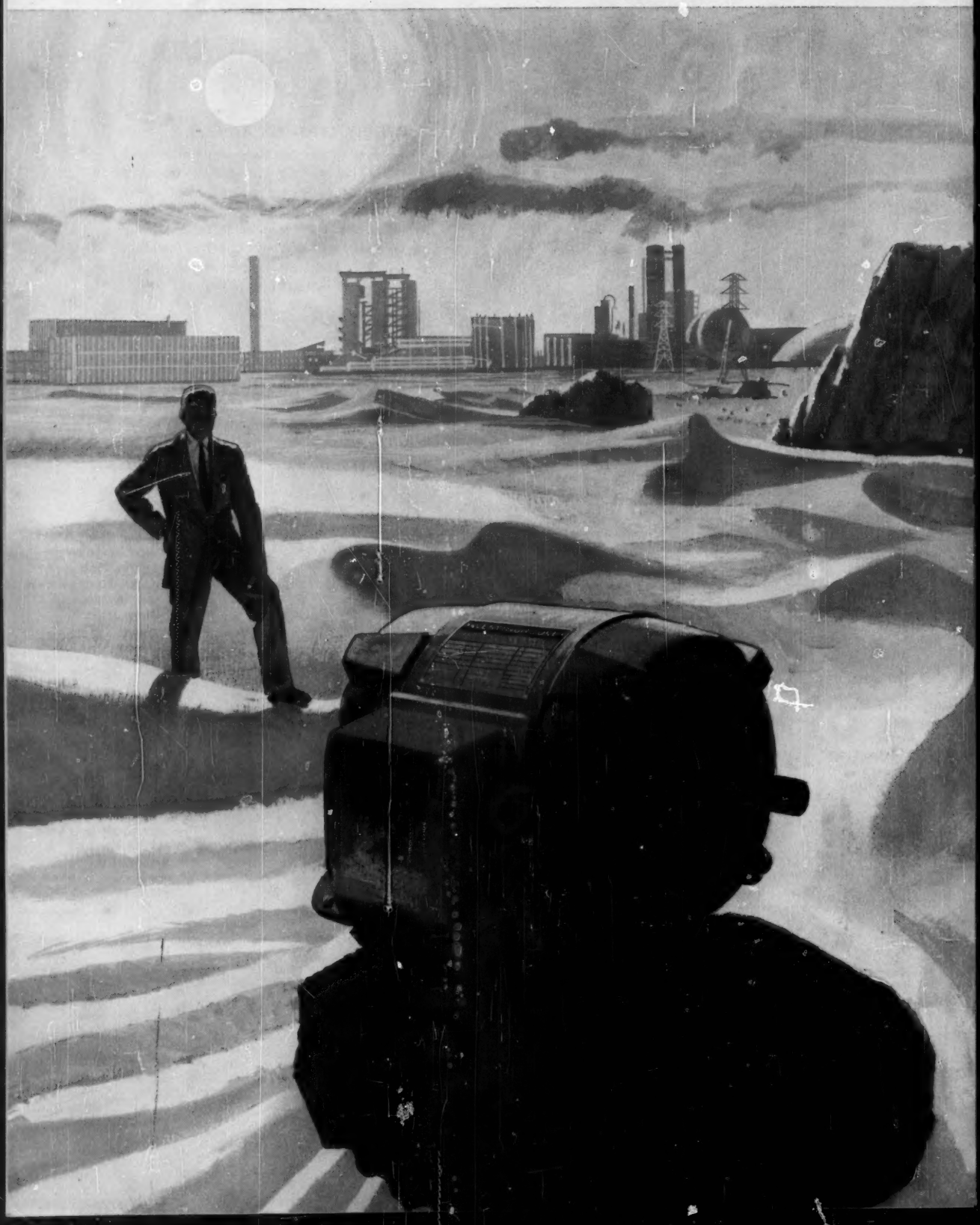
SIZES 1/8″ THROUGH 4″

2000#, 3000#, 4000# and 6000# N.S.C.W.P.

Also STAINLESS, ORIFICE, HANDLEBAR and INSULATED UNIONS

New Guardistor

THE MAN & THE MOTORS



FROM WESTINGHOUSE

Guardistor motors let you match the full capability of the motor to the job— with complete safety—absolute confidence

Our Marketing Manager says:

- "You can match the motor to the load . . . use all the motor you are paying for.
- Provides positive protection based on winding temperature . . . *not* load current and/or power supply fluctuations.
- Eliminates time and expense of changing winter-summer heaters. No nuisance tripping, it's fail-safe . . ."

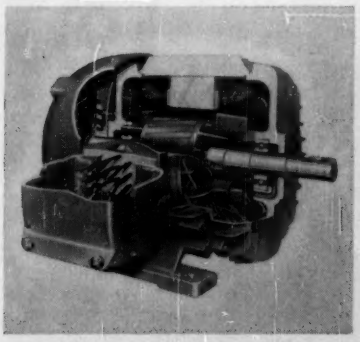
Our Engineering Manager says:

"With the breakthrough development of the Westinghouse Positive Temperature Coefficient thermistors, for the first time we can provide inherent protection against motor failure caused by excessive heat. The solid-state thermistors buried in the windings instantly sense excessive heat from any cause and simultaneously warn of trouble or automatically take the motor off the line. Thus, motor protection is placed where only true motor protection can be . . . in the windings."

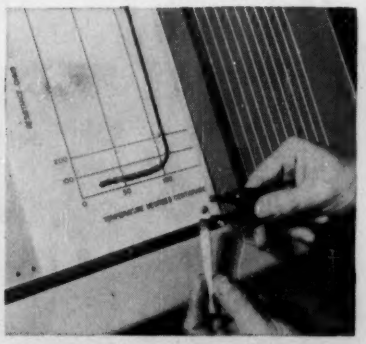
Call your Mr. Westinghouse for the application of a Guardistor* motor to your drive requirements . . . write for *Questions and Answers About . . . Guardistor* (B-7876). Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania.

*Trade-Mark

J-22160



Unlike remotely located sensing devices, PTC thermistors are buried in the windings of the Guardistor motor, instantly equating all temperature factors.



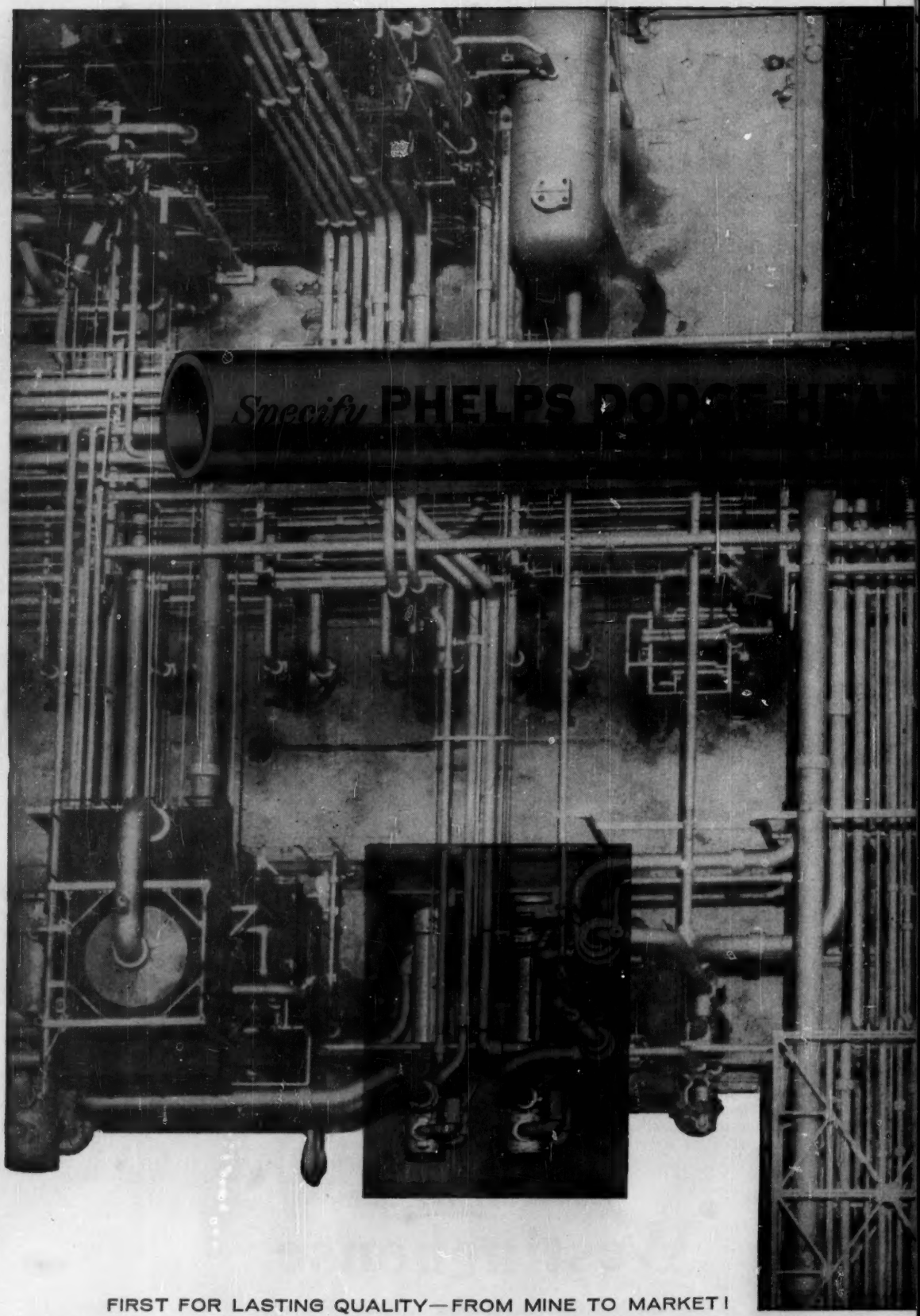
Ever alert PTC thermistors constantly totalize temperature, statically triggering an action *only* if critical temperature is reached.

MOTOR & GEARING DEPARTMENT

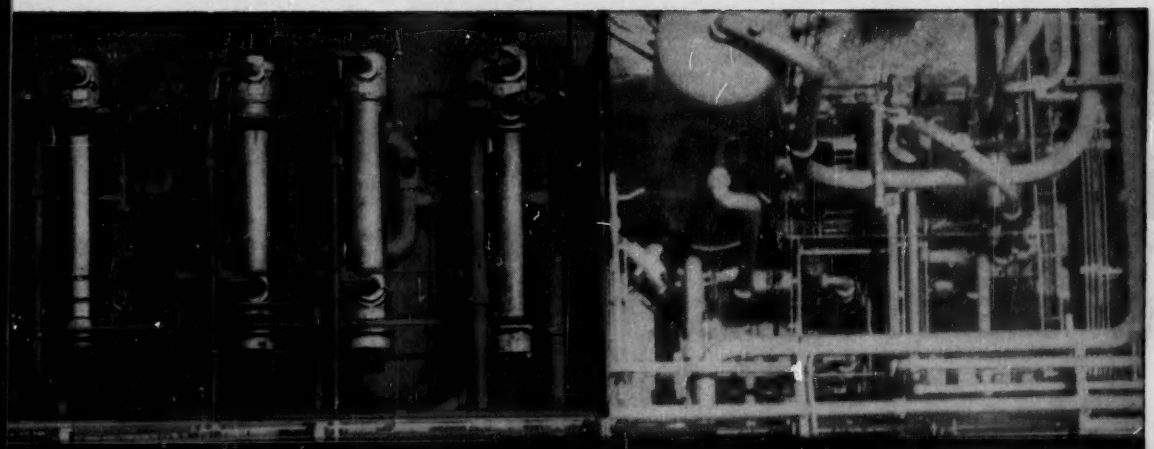
YOU CAN BE SURE...IF IT'S

Westinghouse

TUNE IN WESTINGHOUSE-CBS TV-RADIO COVERAGE, PRESIDENTIAL CONVENTIONS, JULY 10-29



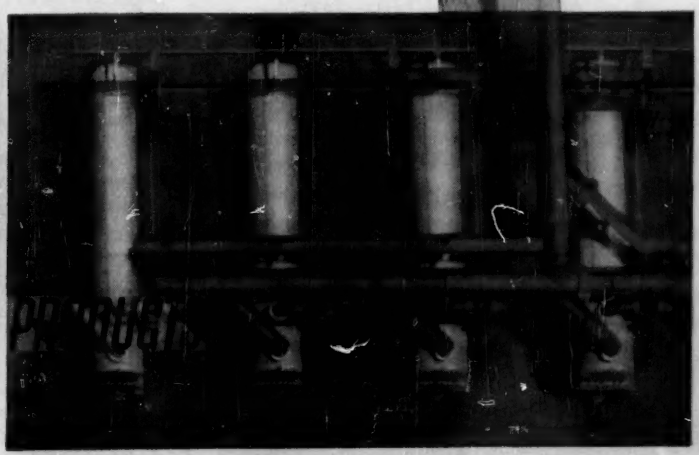
FIRST FOR LASTING QUALITY—FROM MINE TO MARKET!



EXCHANGER TUBES *for Longer Service!*

- Full range of copper-base alloys for every application.
- Vast background of application engineering to assist in proper alloy selection.
- Complete control of quality throughout every step of manufacture.

PHELPS DODGE COPPER PRODUCTS CORPORATION



PHELPS DODGE COPPER PRODUCTS CORPORATION

SALES OFFICES: Atlanta, Birmingham, Ala., Cambridge, Mass., Charlotte, Chicago, Cincinnati, Cleveland, Dallas, Dayton, Denver, Detroit, Fort Wayne, Greensboro, N. C., Houston, Indianapolis, Jacksonville, Kansas City, Mo., Los Angeles, Memphis, Milwaukee, Minneapolis, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Ore., Richmond, Rochester, N. Y., San Francisco, St. Louis, Seattle, Tampa, Washington, D. C.

LUMMUS

ENGINEERS AND CONSTRUCTORS FOR INDUSTRY

NEW SHELL PROCESS ETHYLENE-OXIDE PLANT TO GO ON STREAM FOR OLIN MATHIESON IN 1960

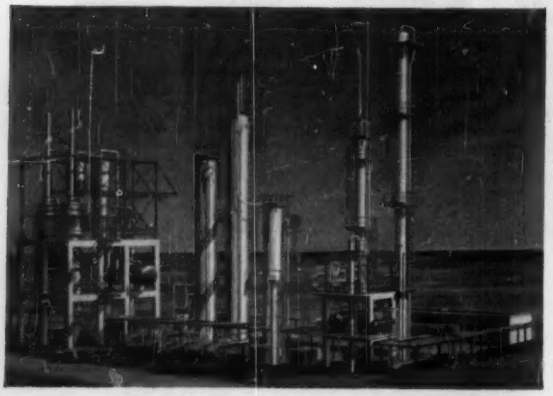
Olin Mathieson Chemical Corporation's new ethylene oxide plant at their Doe Run works, at Brandenburg, Kentucky is scheduled to go on stream late in 1960.

Engineered and constructed by The Lummus Company, the plant will employ the Shell Development Company's process for the direct oxidation of ethylene to ethylene oxide. The ethylene oxide product will be converted into derivatives for use in the manufacture of antifreeze, industrial coolants, hydraulic brake fluids, detergents and chemical intermediates.

Feed for the new plant will come from Olin Mathieson's ethylene plant, also located at Doe Run.

The new plant is part of a recently announced $30 million expansion program for Olin Mathieson's Chemicals Division. It is the fourth Shell process ethylene-oxide plant to be designed, engineered and constructed by Lummus in the last several years. The other three are operated by Calcasieu Chemical Corporation, at Lake Charles, La.; Wyandotte Chemical Corporation at Geismar, La.; and Petrochemicals, Ltd. at Partington, England.

For ethylene oxide and ethylene glycol, or for any type of chemical or petrochemical plant, Lummus' half century of world-wide experience on more than 850 plants for the process industries is at your disposal.



'SHELL' HDS UNIT FOR KOPPARTRANS OLJEAKTIEBOLAG

This Catalytic Desulfurisation Unit for treating 8000 BSD of Catformer feedstock is the latest addition by Lummus to the modern processing facilities at Koppartrans' Gothenburg Refinery. It utilizes the 'Shell' Vapor Phase Catalytic Process and provides the high quality low sulfur naphtha required for the ultimate production of high octane gasoline. Lummus has engineered and built a large number of similar hydrodesulfurisation plants all over the world. This is the latest in Europe. Lummus installed the successful prototype unit for Shell at their Stanlow Refinery in England.

B^2R^2

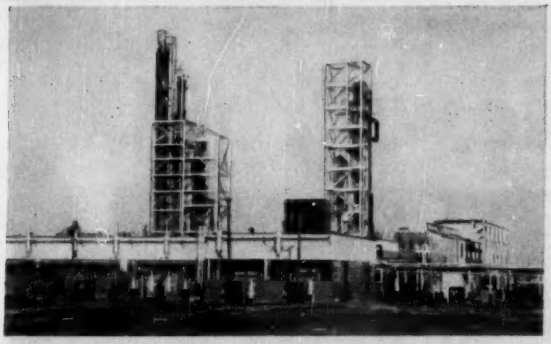
AEC Selects Lummus for Architect-Engineering and Construction Services on $10 Million High Flux Beam Research Reactor

The Atomic Energy Commission has selected The Lummus Company for architect-engineering and construction services on a proposed $10 million research reactor.

At the time of the selection, the A.E.C. said it had chosen the Lummus proposal as a basis for contract negotiations for a 20,000-thermal kilowatt, high-flux reactor. The installation will be built at the A.E.C.'s Brookhaven National Laboratory in Upton, N.Y. Curtiss-Wright Corporation will serve as the nuclear engineering subcontractor to The Lummus Company.

The reactor, authorized by Congress, will produce a high neutron flux—that is, a high intensity of neutrons. It will be used for such research projects as: studying the composition of solid materials, producing isotopes, and research on nuclear particles.

Ethylene Plant Expansion on Stream for Canadian Industries Limited



LUMMUS DESIGNS AND ENGINEERS 85% EXPANSION OF ETHYLENE PLANT AT EDMONTON, ALBERTA, CANADA

Expansion of C-I-L's ethylene facilities at Edmonton, Alberta, Canada, is completed and the plant now has a capacity of 46 million lbs. per year of high purity ethylene. The entire output of this unit is used by C-I-L to manufacture polyethylene.

Lummus designed and engineered the expansion of the existing cracking facilities, built in 1953, for the increased production of ethylene, and the ethane recovery unit for extracting ethane from natural gas.

As originally designed, the plant recovered ethylene from the cracking heater effluent and ethane from natural gas by oil absorption. In the expanded plant, additional capacity is obtained by withdrawing the natural gas portion and increasing the heater effluent.

The new low temperature ethane recovery plant has a demethanization unit which utilizes ethylene refrigeration to temperatures as low as –145°F. At C-I-L's request sufficient capacity has been designed into this unit to permit another expansion step in the future.

Up-to-date equipment was employed to ensure economical and efficient operation. Special efforts were made, wherever possible, to incorporate existing equipment into the expanded plant.

In addition to the C-I-L expansion project, Lummus has designed 13 complete ethylene plants, with a combined total capacity of over one billion pounds per year.

Over a half-century of Process-Industry experience

Here is just a partial list of chemicals for which Lummus has designed, engineered or constructed plants:

Acetone	Dichlorethane	Nitric acid
Acrolein	Dichlorobenzene	Phenol
Allethrin	Di-isobutyl alcohol	Phthalic anhydride
Ammonia	Ethylbenzene	Polyvinyl alcohol
Ammonium nitrate	Ethyl chloride	Polyvinyl pyrrolidone
Ammonium sulfate	Ethylene	Propargyl alcohol
Benzol	Ethylene glycol	Propylene
Beryllium metal	Ethylene oxide	Pyrrolidone
Bisphenol	Epon® resin	Styrene
Butadiene	Formaldehyde	Sulfuric acid
Butanediol	Heavy water	Surfactants
Butynediol	Hydrogen	Tetramer
Butyrolactone	Hydrogen sulfide	Trichlorethylene
Carbon black	Isopropyl alcohol	Trichlorobenzene
Caustic soda	Lamp black	Toluene
Chlorobenzene	Magnesium sulfate	Uranium oxide
Cumene	Mercuric nitrate	Vinyl acetate
Di-ammonium phosphate	Naphthalene	Vinyl pyrrolidone

Discuss your next chemical or petrochemical project with a Lummus representative.

THE LUMMUS COMPANY, 385 Madison Avenue, New York 17, N. Y.; Houston, Washington, D. C.; Montreal, London, Paris, The Hague, Madrid. **Engineering Development Center:** Newark, N. J.

Lummus Appoints General Creasy To Head New York Division

DR. S. Z. AVEDIKIAN SUCCEEDS CREASY AS DIRECTOR OF ENGINEERING DEVELOPMENT CENTER

Major General William M. Creasy (U.S. Army retired) — who has been appointed to head Lummus New York Division.

William M. Creasy—Major General, U.S. Army retired – a Vice President of The Lummus Company, has been appointed to head the company's New York Division. At the same time, Dr. S. Z. Avedikian is joining The Lummus Company as Director of the Engineering Development Center in Newark, New Jersey. He succeeds General Creasy, who was formerly Director of the Engineering Development Center.

Previous to joining Lummus in 1958, General Creasy had served as Chief Chemical Officer of the Army since 1954. In this position, he was in charge of the Army Chemical Corps, whose activities include large-scale research and development, engineering, training and procurement in chemical, biological and radiological warfare. General Creasy received his B.S. degree from the United States Military Academy in 1926, and an M.S. degree in Chemical Engineering Practice from M.I.T. in 1936.

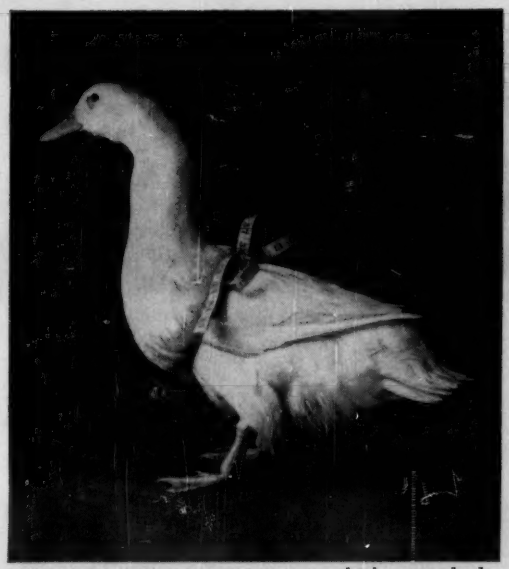
Dr. S. Z. Avedikian—Appointed Director of Lummus Engineering Development Center.

Before joining Lummus, Dr. Souren Z. Avedikian of Princeton, New Jersey, was co-founder of Avedikian and Company in 1932, Tidings Corporation of America in 1947, and S. Z. Avedikian & Associates in 1959. Holder of about 30 U.S. and foreign patents, Dr. Avedikian has been engaged in the research and development of processes and products for over 25 years, concentrating in heavy and fine chemicals, plastics, textiles, pharmaceuticals, paper, food processing, and amalgam cells.

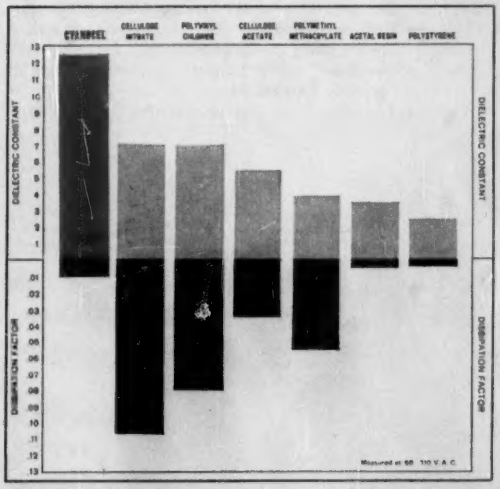
CYANAMID

Chemical Newsfront

TAIL-LIGHTS ARE ON THE BEAM with Cyanamid's exciting new CALCO® OIL RED ZMQ dye. Tailor-made for the thermoplastic market, this new product is unexcelled for tail-lights and other signalling devices, indoors or out . . . wherever a clear, bright, absolutely *light-fast* red is vital. These are some of the big advantages of Calco Oil Red ZMQ: *Purity*—triple recrystallization; *Cleanliness*—less than 50 ppm of heavy metals; *Softness*—cuts process time; *Brightness*—higher than current standards; *Dispersion*—excellent. **(Dyes Department)**

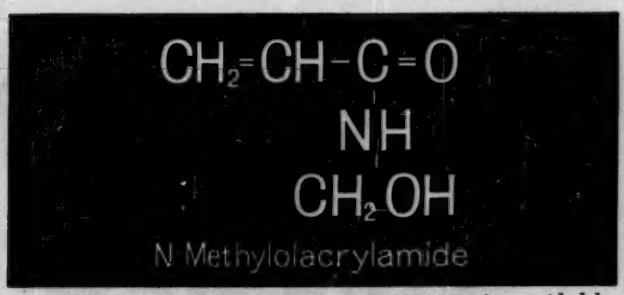


WATER REPELLENT FINISH MEASURES UP to highest standards. In addition to superior Initial Spray Ratings and unusual durability, Cyanamid's CYANA® PERMEL PLUS® finish offers other important advantages to treated fabrics. These are: *spot and stain resistance; wrinkle resistance; choice of hand—crisp to soft; fabrics lie flat on table for easier cutting and sewing.* Packed with these big extras, fabrics treated with Cyana Permel Plus are building sales for their many users in the textile industry. **(Textile Chemicals Department)**



ELECTRIFYING NEWS! Cyanamid research has developed a chemically modified cellulose with remarkable electrical properties. Trademarked CYANOCEL®, the new product can be cast into film—molded at high temperatures and pressures. Graph (above) demonstrates the unusually high dielectric constant of CYANOCEL and low dissipation factor. Flexibility, physical strength and transparency, combined with outstanding electrical properties, make CYANOCEL particularly interesting to the electrical and electronic fields. **(Petrochemicals Department)**

*Trademark



EASY ROUTE TO TOTALLY METHYLOLATED COPOLYMERS is provided by Cyanamid's methylolacrylamide. Instead of the half to two-thirds conversion expected from the methylolation of acrylamide copolymers, use of methylolacrylamide will give a completely methylolated system. Drum quantities are now available from stock. While the normal shipping form is a 60% aqueous solution, we would gladly discuss the possibility of making methylolacrylamide available in other concentrations or solvent systems to meet specific requirements. **(Market Development Department)**

FREE BOOKLET ON PIMELIC ACID. Pimelic Acid, the seven carbon straight chain dibasic acid, is now available from Cyanamid in developmental quantities. This product has the lower melting point and greater solubility characteristic of dibasic acids with odd numbers of carbon atoms. A white crystalline solid, it reacts, for example, to form amides that can be easily dehydrated to nitriles. Pimelic acid should be of particular interest to researchers concerned with polyesters, polyamides and plasticizers. Cyanamid's booklet *"Pimelic Acid"* lists complete properties and potential uses. For your copy check the coupon below. **(Petrochemicals Department)**

For further information on products in this advertisement wire, phone—or mail this coupon to:

AMERICAN CYANAMID COMPANY CE-70
30 Rockefeller Plaza, New York 20, N. Y.

Please send me additional information on

- ☐ CALCO® OIL RED ZMQ DYE
- ☐ CYANA® PERMEL PLUS®
- ☐ CYANOCEL* Modified Cellulose
- ☐ Methylolacrylamide
- ☐ PIMELIC ACID

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CYANAMID

AMERICAN CYANAMID COMPANY

30 ROCKEFELLER PLAZA, NEW YORK 20, N.Y.

3 All New electric

. . . to make

FEATURES:

- Wide band adjustments: 0 to 500% prop. band, 0 to 100 repeats/min. reset, and 0 to 10 min. rate.
- Bumpless transfer even when control output is changing.
- Change proportional band any amount without upsetting process.
- Rate action circuit minimizes overshoot in batch process and during startup.
- Pull-out chassis for servicing without interrupting operation.
- Modular construction simplifies maintenance and stocking.
- Plug-in silicon diode rectifiers for greater reliability.

All three units use the same plug-in components . . . only the control output section is different. Simplifies on-the-job servicing . . . eliminates need for complicated test equipment.

3-mode control units

furnaces perform at their best

***Electr-O-Line* Control Unit**—For electronic position-proportioning control with reset and rate action

***Electr-O-Pulse* Control Unit**—For electronic time-proportioning control with reset and rate action

***Electr-O-Volt* Control Unit**—For electronic current output proportioning control with reset and rate action

One of these units—*Electr-O-Line, Electr-O-Pulse* or *Electr-O-Volt*—will deliver the exact kind of temperature control that's best for your furnace.

Plug-in construction is used throughout all three units—including common amplifier and power supply sections. Operator adjustments are exactly alike for all three units. Interchangeability of control output sections simplifies stocking and service problems.

Get complete details on these and other types of furnace controls from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

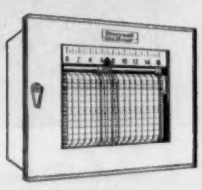
Honeywell

First in Control

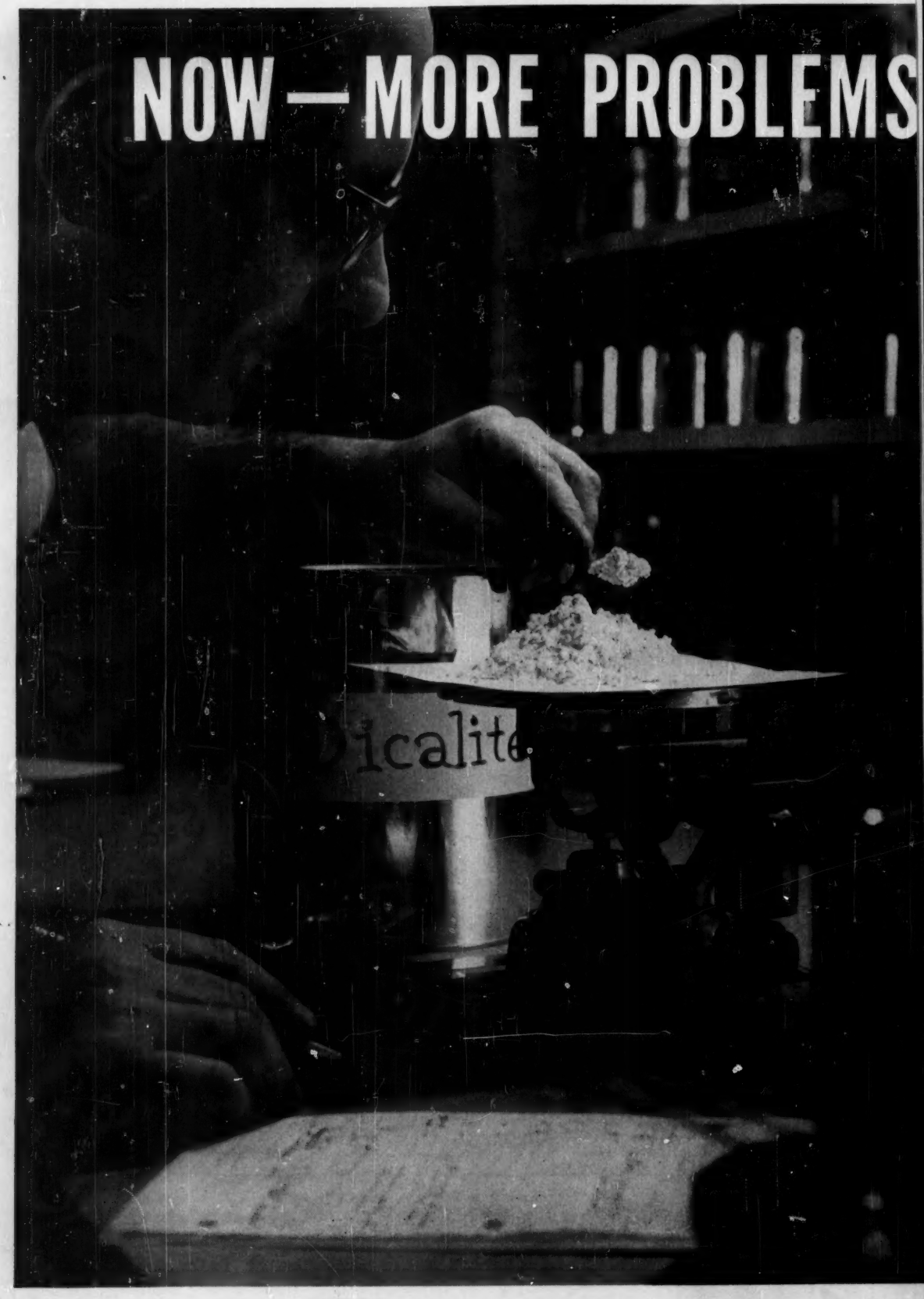
SINCE 1885

75th YEAR

PIONEERING THE FUTURE



Use *ElectroniK* strip chart, circular chart or circular scale controllers to actuate *Electr-O-Line, Electr-O-Pulse* or *Electr-O-Volt* units. They are integrally mounted, simplifying panel cutout and reducing wiring costs.


NOW—MORE PROBLEMS

SOLVED WITH DICALITE FILLERS

NEW MATERIALS INCREASE RANGE OF APPLICATIONS

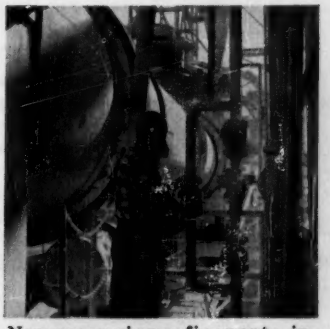
Dicalite has added new products to its family of filler materials, as well as new quality control measures. Now, diatomite, perlite and carbon-based materials are available to meet industry's widest range of filler applications.

Because of their unique particle structure and their physical and chemical properties, Dicalite filler materials are used in a tremendous variety of ways—in paint, paper, rubber, plastics, resins, cements, fertilizers, insecticides, horticultural mediums, as catalyst carriers, absorbents, etc.

They offer tremendous surface area and porosity, great bulk in relation to weight, high absorptiveness, and structural reinforcement in many uses. All are chemically and physically stable in practically all applications. Diatomite is used in many high temperature insulations; perlite is especially effective in cryogenic applications.

Dicalite filler materials may provide an answer to your filler problem. Call the Dicalite man and see.

Careful strata selection provides the best crude for each product's final requirements.



New processing refinements, including special calcining methods, control product characteristics with an accuracy never before possible in any plant.

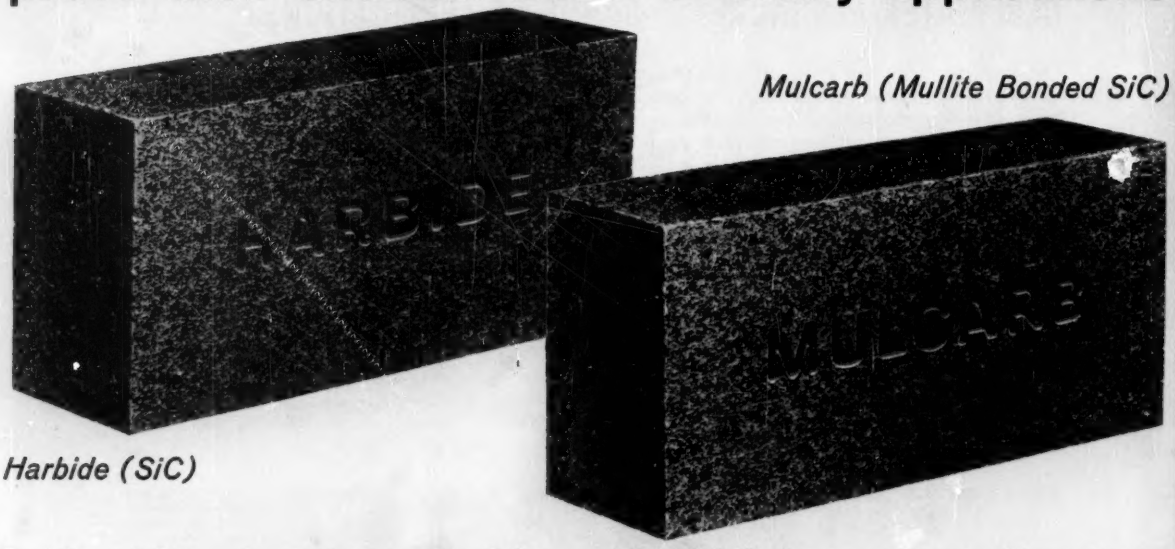
With more than 22,000 quality control tests every month, the Dicalite plant laboratories hold every product grade to rigid specifications.

New automatically-controlled packing and pressure-palletizing is the final step in efficient modern operation.

Dicalite®
Dicalite Department
Great Lakes Carbon Corporation
612 So. Flower Street, Los Angeles 17, Calif.

I am interested in these aspects of filler materials
☐ Bulking ☐ Structural ☐ Extender ☐ Carrier ☐ Insulation
Type of product or material _____
☐ Send information ☐ Have Dicalite man phone for appointment
NAME _____
TITLE _____
COMPANY _____
ADDRESS _____
CITY _____ ZONE _____ STATE _____
CE-2

HARBISON-WALKER
SILICON CARBIDE REFRACTORIES
prove their unusual worth in many applications



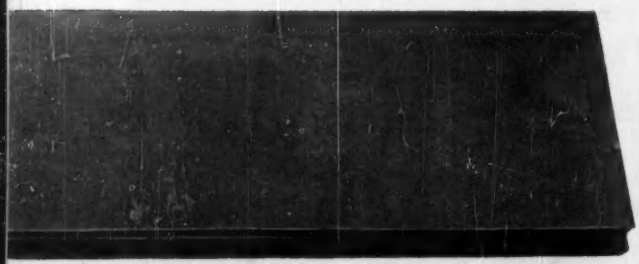
Mulcarb (Mullite Bonded SiC)

Harbide (SiC)

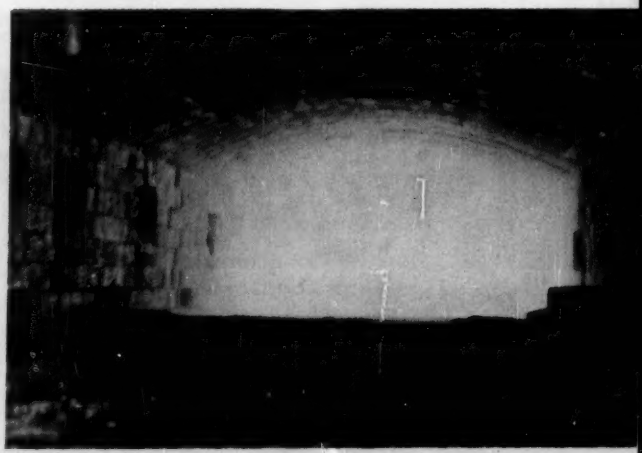
By taking advantage of particular properties of these brands and their specialized modifications for various specific uses, excellent service is regularly secured. These benefits are attributable to the singular combinations of physical and chemical properties of these silicon carbide refractories, unmatched by the many other types and classes of commercial refractories.

Physical properties possessed to the maximum degree by Harbison-Walker silicon carbide refractories make them best suited for many uses. Briefly these properties are—High Thermal Conductivity—Great Resistance to Mechanical Abrasion over a wide range of temperatures—Resistance to Various Fluxes—High Temperature Strength—Low Thermal Expansion and Low Spalling Tendency. Their increased resistance to oxidation and their volume stability under severe temperature conditions contribute further to the noteworthy achievement in the development of these Harbison-Walker brands.

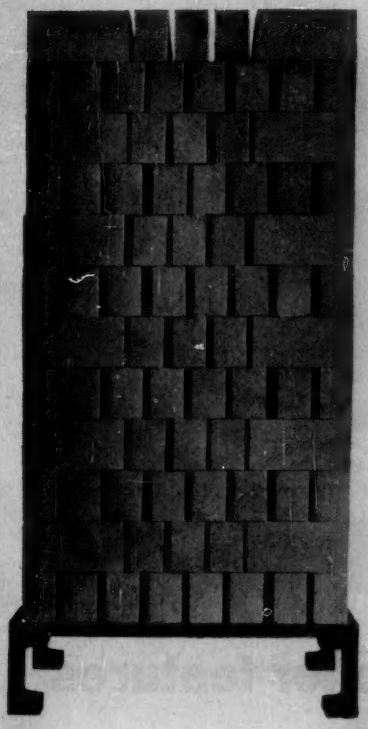
Illustrated in the following are typical uses and properties of primary importance in the accomplishment of superior results in refractory practice:

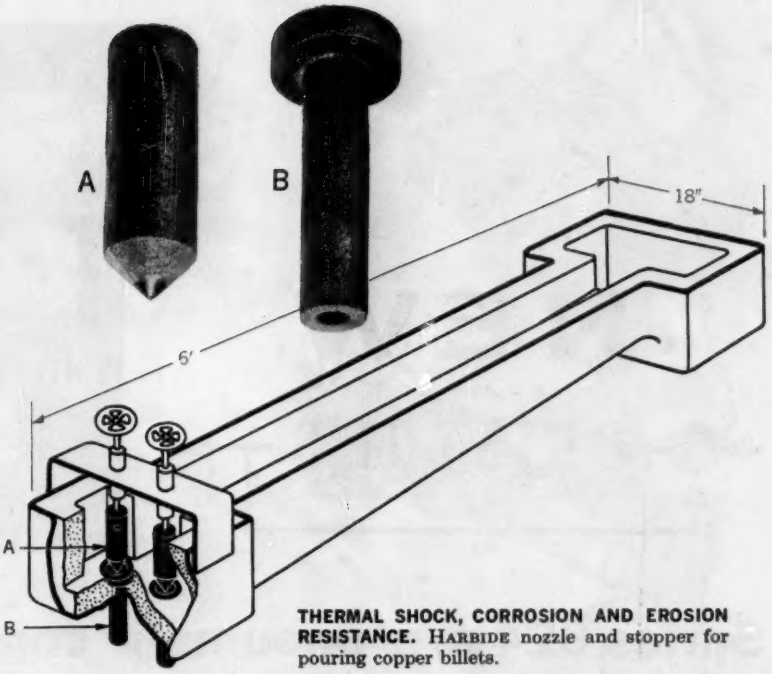


HIGH THERMAL CONDUCTIVITY. Large thin HARBIDE muffle tile for zinc refining furnace.



ABRASION RESISTANCE. HARBIDE blocks after long service in floor of heating furnace.





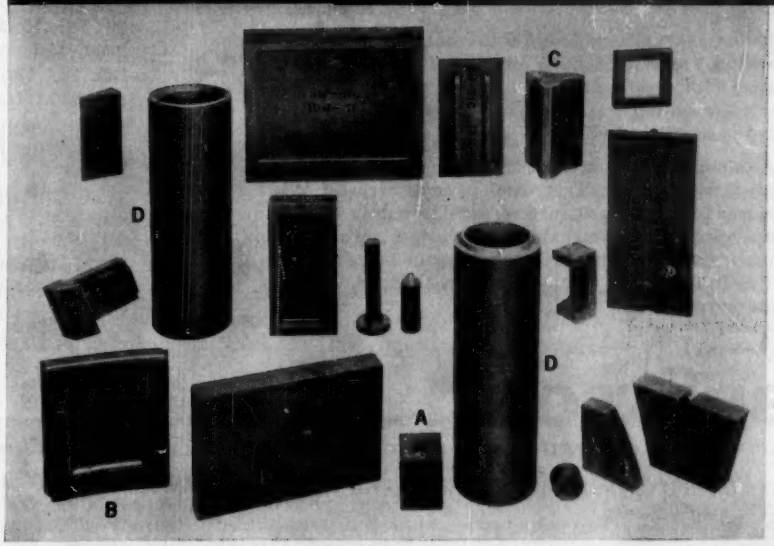
THERMAL SHOCK, CORROSION AND EROSION RESISTANCE. HARBIDE nozzle and stopper for pouring copper billets.

HIGH TEMPERATURE STRENGTH. HARBIDE setter tile and supports, with heavy brick load, fired at Cone 18 makes many trips through tunnel kiln.

CORROSION RESISTANCE. Protection against burning, with advantage of high heat transfer.

RESISTANCE TO DUST ATTRITION. (far right) Plate-type HARBIDE orifice for blast furnace raw gas scrubber.

VERSATILITY. Group of H-W silicon carbide shapes shown below, right, includes (A) tapping block (B) muffle tile (C) trefoil skid rail and (D) large tubes.



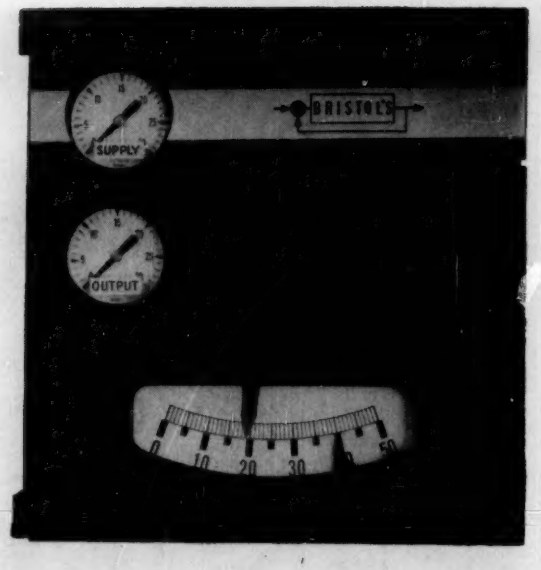
HARBISON-WALKER REFRACTORIES COMPANY *AND SUBSIDIARIES*

General Offices: Pittsburgh 22, Penna.

World's Most Complete Refractories Service

HW-60-15

NEW BRISTOL'S



Series 624 A/D* pneumatic controller features simplicity and high control stability

- **Simple modular design for ease of servicing**
- **High control stability for closer process control**
- **Designed for batch-type and continuous processes**
- **Proportional and proportional-plus-reset control models available**

Top control performance with maximum simplicity plus standard Bristol precision measuring elements—those are the key features of the Bristol Series 624 Controller. The 624 uses the same renowned elements that have earned such a reputation for accuracy and dependability on other Bristol automatic controlling and recording instruments—perfected through wide experience and many years of development.

Self-contained modular design of the control unit speeds servicing. The whole modular unit, consisting of an aluminum casting with working parts made of stainless steel, Ni-Span C, and Neoprene diaphragms, can be removed by taking out only two screws and a link.

Outstandingly compact, the aluminum instrument case (only 8" x 8" x 5" overall) is completely weatherproof. It is designed for either flush, surface, panel, or valve mounting. Attachments for pipe mounting (2-inch pipe) are available. Write for complete data on the versatile and economical 624 A/D. The Bristol Company, 109 Bristol Road, Waterbury 20, Conn. 0.35

**Advanced Design*

CONTROLLERS OFFERED FOR:

PRESSURE AND VACUUM: Ranges from full vacuum to 10,000 psi.

TEMPERATURE: Ranges from —100°F to +1000°F.

FLOW AND DIFFERENTIAL PRESSURE: With mercury-type manometer and dry-type differential unit.

LIQUID LEVEL: With bulb unit and mercury manometer and dry-type differential unit.

HUMIDITY: Zero to 100% relative humidity.

CONTROL UNIT CHARACTERISTICS:

PROPORTIONAL BAND: 0-400% continuously adjustable, direct- or reverse-acting.

RESET: 0.1 to 50 repeats per minute.

AIR PILOT: Non-bleed type.

PILOT CAPACITY: 4.0 scfm.

FREQUENCY RESPONSE: Flat to 400 cycles per minute.

TEMPERATURE STABILITY: Less than 0.1% change in the output pressure for 90°F temperature change.

MATERIAL: Aluminum housing; 316 stainless steel internal parts; Ni-Span C feedback element.

BRISTOL... for improved production through measurement and control

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

ONE OF A SERIES

Printed by offset lithography on 80-lb. paper containing Wyandotte PURECAL® in the coating.

Can Wyandotte technical service make a sick product well?

In many cases, it can . . . but letting a product get sick in the first place is costly business at best.

Moral: Don't hesitate to call on technical service when things are going smoothly. One of the most valuable functions it can perform for you is to spot *potential* trouble.

It is available to you at raw-material procurement, research, development, manufacturing, sales, and shipping levels.

It draws on the manifold skills of Wyandotte's entire organization . . . chemists, chemical engineers, physicists, and many other specialists with extensive industrial or research experience in specific product fields.

It has much to contribute to all phases of your quality-control program.

But . . . we realize that critical problems can arise without warning in the best controlled operations. This is why our technical service is geared to meet emergencies. It knows no hours. We have qualified men on duty round the clock.

Is this 24-hour availability really necessary? We think so . . . for it has proved helpful, many times. And this, fundamentally, is the aim of technical service . . . to be helpful, in any way possible.

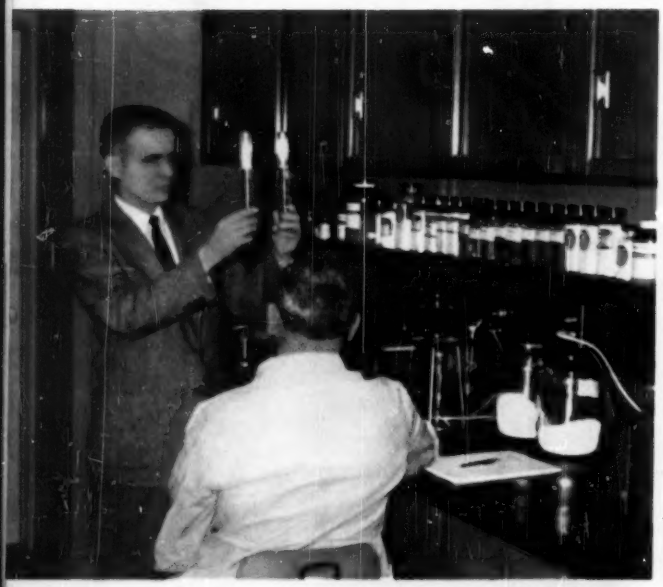
For a pictorial presentation of Wyandotte technical service at work, please turn page.

WYANDOTTE CHEMICALS

SODA ASH • CAUSTIC SODA • BICARBONATE OF SODA • CALCIUM CARBONATE • CALCIUM CHLORIDE • CHLORINE • MURIATIC ACID • HYDROGEN • DRY ICE GLYCOLS • SYNTHETIC DETERGENTS • SODIUM CMC • ETHYLENE OXIDE • ETHYLENE DICHLORIDE • POLYETHYLENE GLYCOLS • PROPYLENE OXIDE PROPYLENE DICHLORIDE • POLYPROPYLENE GLYCOLS • DICHLORODIMETHYLHYDANTOIN • CHLORINATED SOLVENTS • OTHER ORGANIC AND INORGANIC CHEMICALS

Improving the performance of detergents

. . . an example of Wyandotte technical service at work



1 A household detergent manufacturer, seeking greater whiteness retention and detergency for a new laundry product, called in Wyandotte technical service. Addition of Carbose®, Wyandotte's special grade of CMC, designed specifically to improve whiteness retention, is indicated; varying amounts are tried in sample formulations.

2 In the Wyandotte nucleonics laboratory, soil-suspension efficiency is tested by tagging soil with radioactive isotopes. Fabric swatches coated with this soil are then washed in the new formulations to determine which performs best. Precise cleaning performance is measured by the amount of residual radioactivity detected by a Geiger counter.

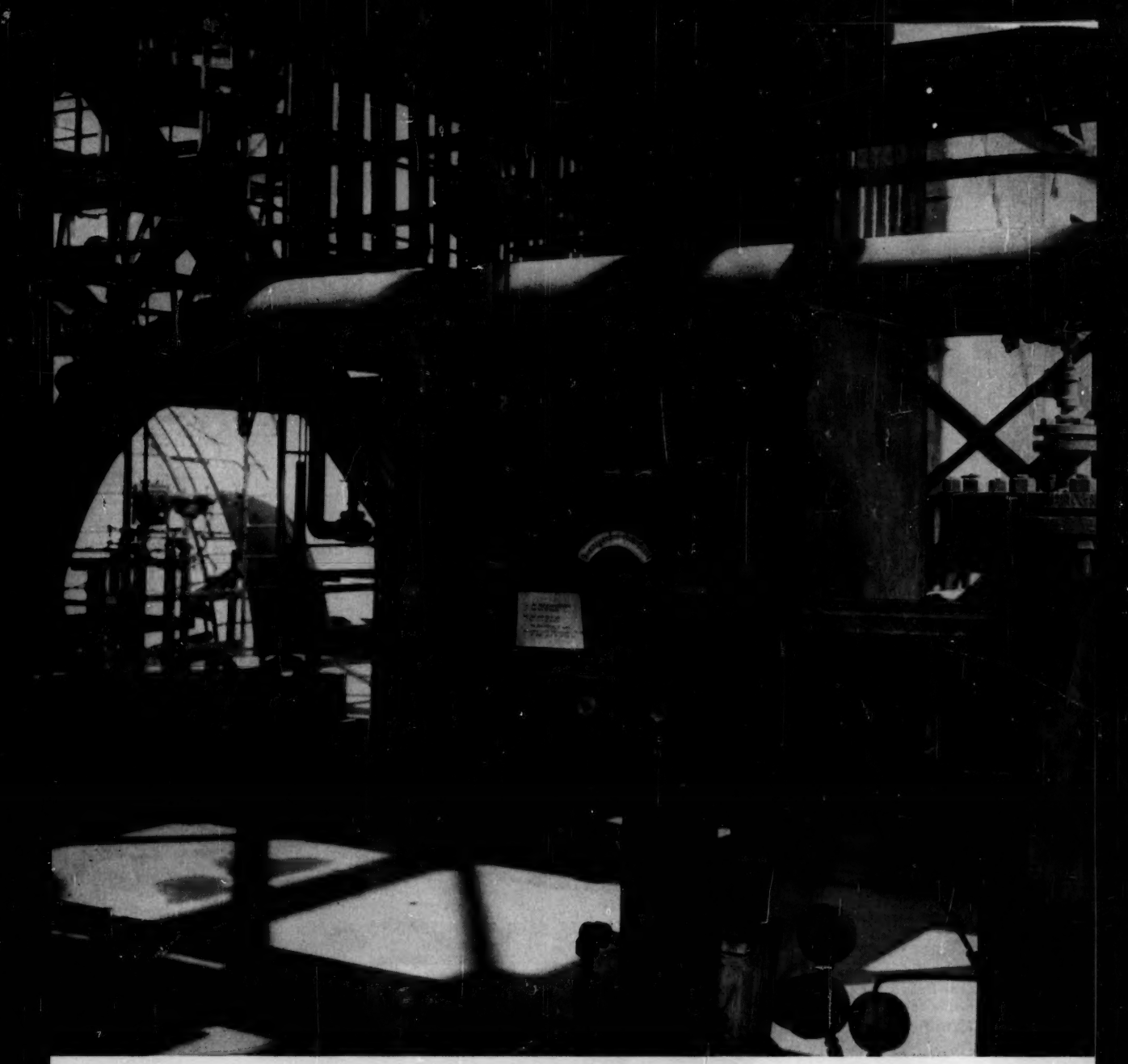
3 One of the samples tested proves to have the desired properties, and the formulation is submitted to the interested company. A carload order is placed, and Wyandotte technical service works with the company to arrive at the most economical and convenient method of shipping the Carbose . . . in this case, palletizing.

HELPING DETERGENTS do a better job is just one of the many ways technical service aids Wyandotte customers and prospective customers in the soap and detergent industry. Our experience encompasses many industries: plastics, pulp and paper, petroleum, paint, textiles and rubber, to name a few. If you have a problem that falls within our technological or manufacturing background, check with us . . . our approach is designed to provide answers. *Wyandotte Chemicals Corporation, Michigan Alkali Division, Wyandotte, Michigan. Offices in principal cities.*

Wyandotte
CHEMICALS

Pacing Progress with Creative Chemistry ®

833



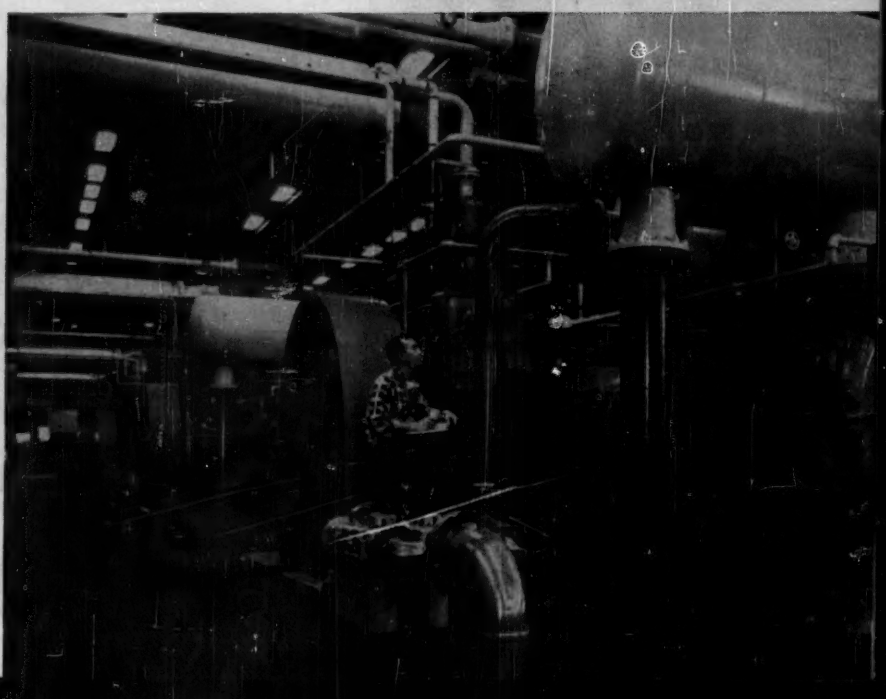
The sentinel that never gets relief... Day after day after day, for over 4 years this Beckman oxygen analyzer has maintained vigil on catalyst regeneration. Located eight stories above The Texas Company refinery at Wilmington, California, it has monitored unreacted oxygen, under demanding conditions, with only minimum routine maintenance. Analysis must be continuous, dependable, accurate. ⌘ This Beckman instrument is the only oxygen analyzer to use a direct paramagnetic measurement exclusively, which brings you these advantages: *Dependability...* under the most rugged conditions. *Simplicity...* with no auxiliary measurements to complicate analysis, no extra components requiring extra maintenance. *Accuracy...* with sensitivity and specificity to meet the most critical process requirements. ⌘ Whatever your application, if you want detailed specifications on an oxygen analyzer that withstands tough environments and gives you continuous, dependable answers, ask for Data File 14-29-08

INSTRUMENTAL IN YOUR FUTURE 25 YEARS 1935-1960

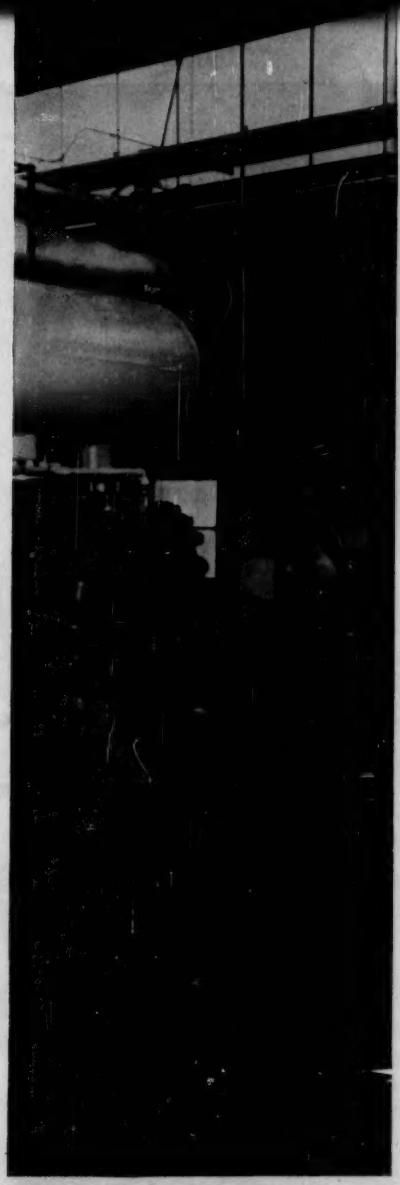
Beckman®
Scientific and Process Instruments Division
Beckman Instruments, Inc.
2500 Fullerton Road, Fullerton, California

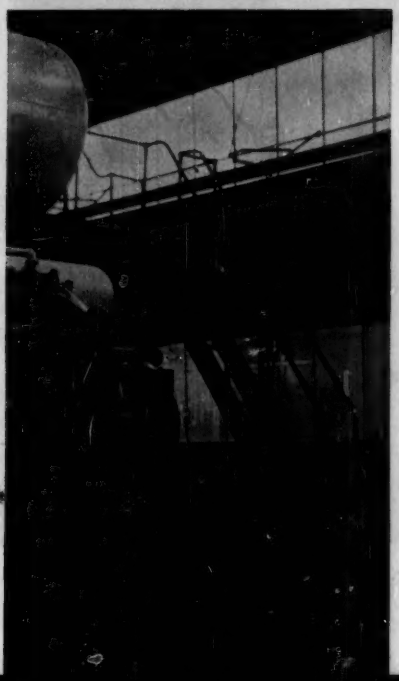
It's a Fact: A Beckman Infrared Analyzer has successfully controlled heat input to a refining tower for three years, maximizing ethylene recovery and minimizing methane content by analysis of the bottoms of a demethanizing absorber.

Cooper-Bessemer compressor shown is one of two units for compression of synthesis gas.



View showing the four Cooper-Bessemer compressors. Unit in foreground is for "mixed gases" (air, nitrogen and methane).





Henry LaRue, *Ammonia Area Superintendent, Spencer Chemical Company, Vicksburg, Mississippi explains...*

How we compress four different gases with a team of four Cooper-Bessemer compressors

"Our entire ammonia plant depends on the uninterrupted flow of component gases, compressed by four Cooper-Bessemer GMW-8 Compressors," reports Mr. LaRue. "These four 2000 hp gas engine driven units have been the heart of our system 24-hours a day, day in and day out, since 1953.

"Two of the compressors, with five cylinders each, compress three different gases... air, nitrogen and methane. The other pair of compressors pump a synthesis gas mixture of hydrogen and nitrogen.

"Despite their 'round-the-clock operation for seven years, none of these Cooper-Bessemer compressors has had a major down-time for maintenance. They represent a sound investment."

Cooper-Bessemer engineers are at your service to help you plan compression and power facilities. Call the nearest office.

BRANCH OFFICES: Grove City • New York • Washington • Gloucester • Pittsburgh Chicago • Minneapolis • St. Louis • Kansas City • Tulsa • New Orleans • Shreveport • Houston Greggton • Dallas • Odessa • Pampa • Casper • Seattle • San Francisco • Los Angeles

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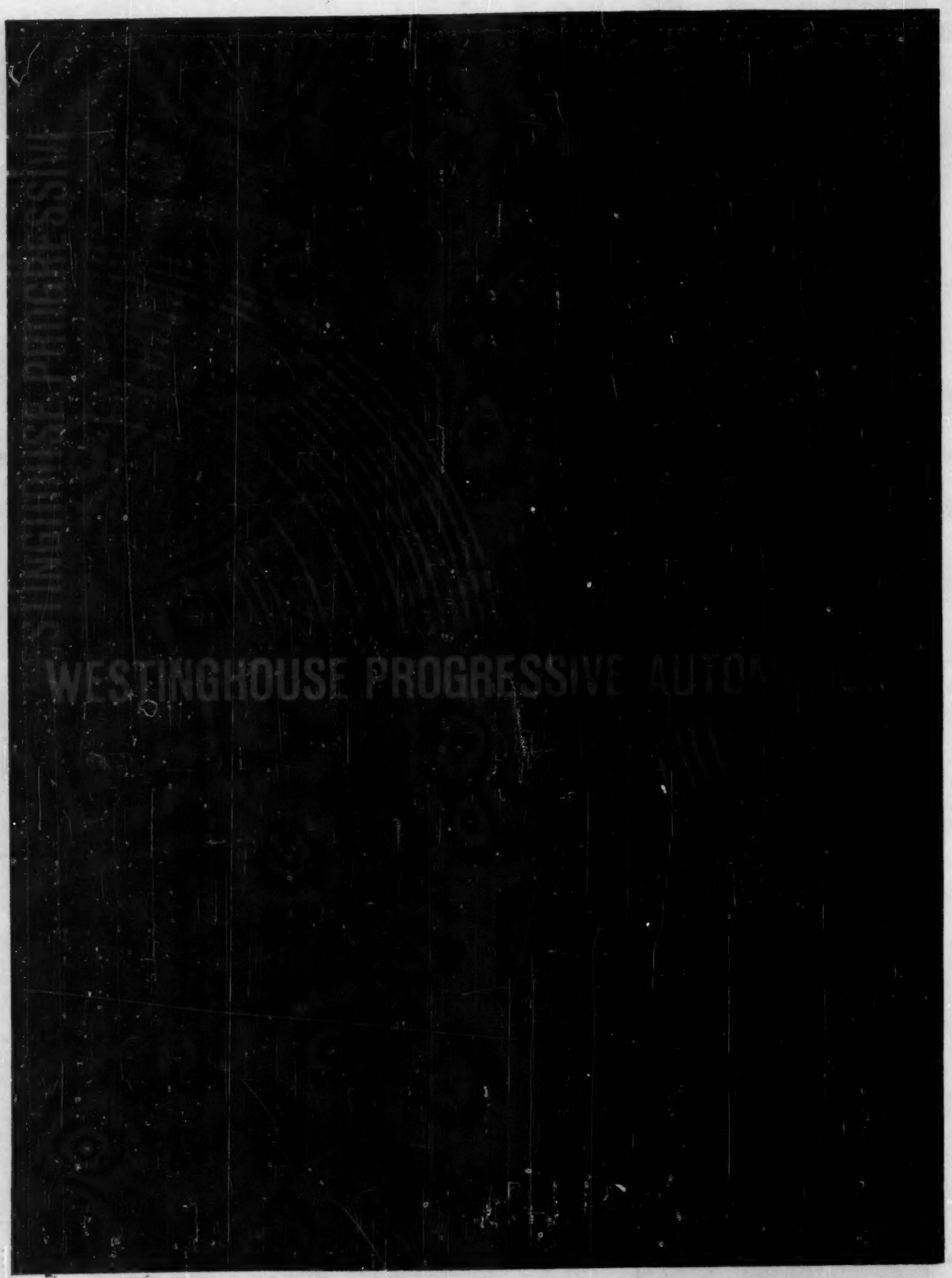
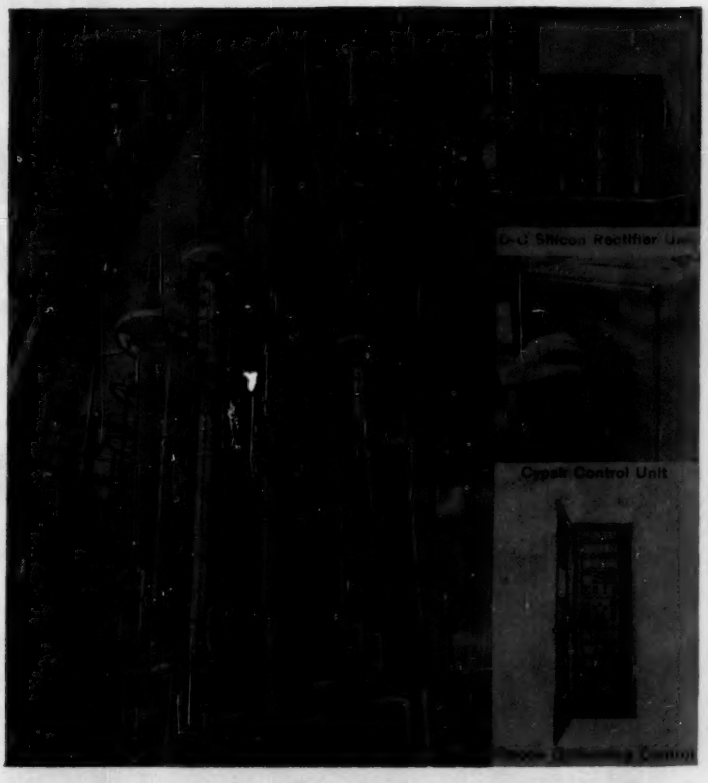
ENGINES: GAS • DIESEL • GAS-DIESEL
COMPRESSORS: RECIPROCATING AND CENTRIFUGAL, ENGINE, TURBINE OR MOTOR DRIVEN


WESTINGHOUSE PROGRESSIVE AUTO



WESTINGHOUSE PROGRESSIVE AUTOMATION CAN HELP YOU ACHIEVE PLANT FLEXIBILITY, INCREASED POWER EFFICIENCY, ACCURATE PROCESS CONTROL

Rapid changes in chemical processing techniques represent the major problem confronting the industry. How to optimize profits from the present plant investment? How to utilize existing facilities when newer production processes are developed?

Westinghouse is ready to help you plan *economical steps* to automatic production, to achieve your goals without over- or under-automating. Westinghouse Progressive Automation is an individualized plan to gain higher product quality through step-by-step control of operations... a long-term plan with minimum capitalization.

The dynamic growth of the entire chemical industry finds many electrical systems badly overloaded without adequate protection . . . and narrowly limited to adaptability to changing electrical needs. Powering-Up with an adequate electrical system is a logical first step (on the road to fully automatic production) recommended by Westinghouse.

To help the industry provide more efficient means of supplying the large blocks of direct current, Westinghouse developed the silicon rectifier for all voltages. Compared to other types of rectifiers, the high efficiency of Westinghouse silicon rectifiers permits power savings of $50,000 in a typical installation rated 100,000 amps, 300 volts d-c.

Chemical plants have found almost 100% reliability in their control panels with the addition of the Westinghouse Cypak® . . . static switching unit which provides extremely reliable process control tailored to meet your existing and growing needs for automatic operations.

Combining groups of control loops is already being investigated in experimental chemical plant installations. This advanced stage of automatic production utilizes data logging and digital computers.

Before maximum automation is practical in the chemical industry, two steps must be accomplished: more direct measurement of variables, and development of additional process data.

Additional Westinghouse experience to guide you in automating your plant was gained in production of *Prodac**. . . first applied to automatic steel-mill rolling. Opcon,* an associated development, experimentally controls process variables to select the *optimum* operating conditions.

And when widely separated functions are ready for central control, look to Westinghouse for experience and equipment for industrial communication and control through multiplex telemetering and microwave transmission.

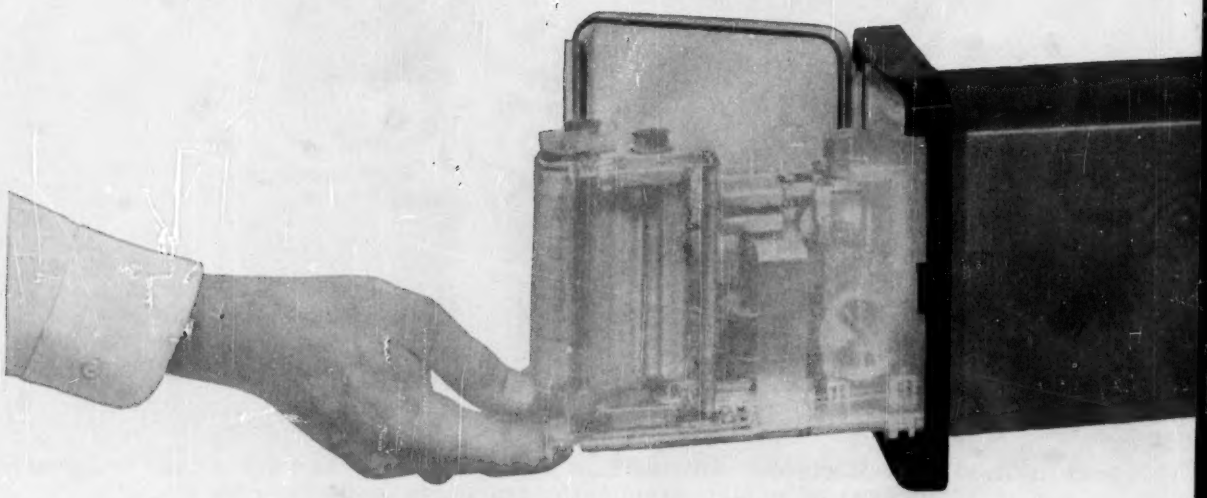
Today, and for the first time, there is *one* source for control and computer systems and all basic electrical equipment for the chemical industry. Call your local Westinghouse representative for complete information on PROGRESSIVE AUTOMATION. J-96145-R

*Trade-Marks

YOU CAN BE SURE... IF IT'S Westinghouse

TUNE IN WESTINGHOUSE-CBS TV-RADIO COVERAGE, PRESIDENTIAL CONVENTIONS, JULY 10-29

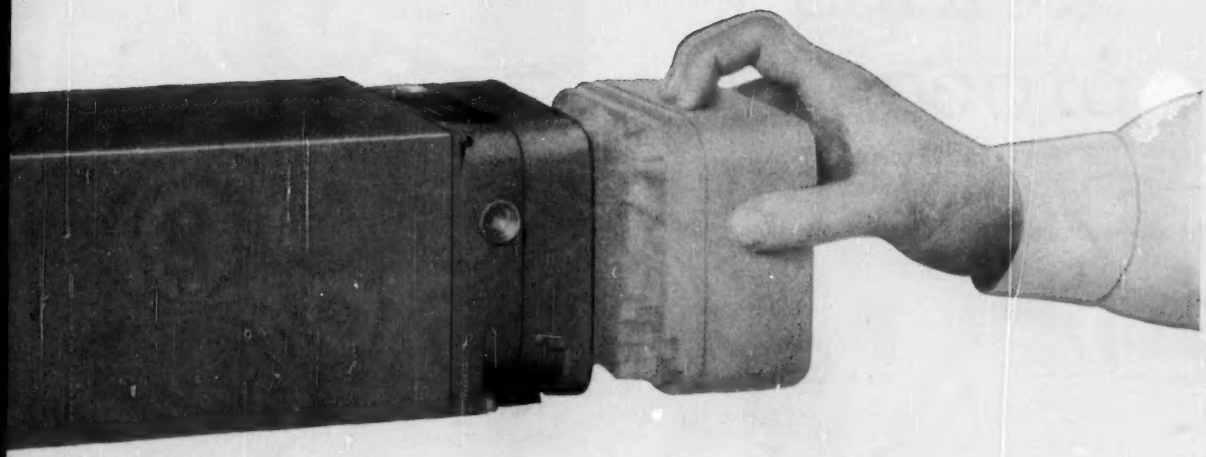
NEED THE BEST MINIATURE



Now we can give you 2 to 4 weeks delivery on TRANSCOPE® pneumatic and electronic recorder housings

Taylor Instruments

RECORDERS IN A HURRY?



Ready for instrumentation—but no instruments? Here is good news! We will ship you TRANSCOPE housings with manifolds within 2-4 weeks of receipt of your order. The unique plug-in features of the 90J pneumatic and 700J electronic recorders and TRANSCOPE controllers enable you to install these housings and make all necessary connections to the tagged manifolds while we complete manufacture of the instruments. You will then be ready to plug in recorders on delivery—approximately 4-6 weeks later—and be on stream immediately.

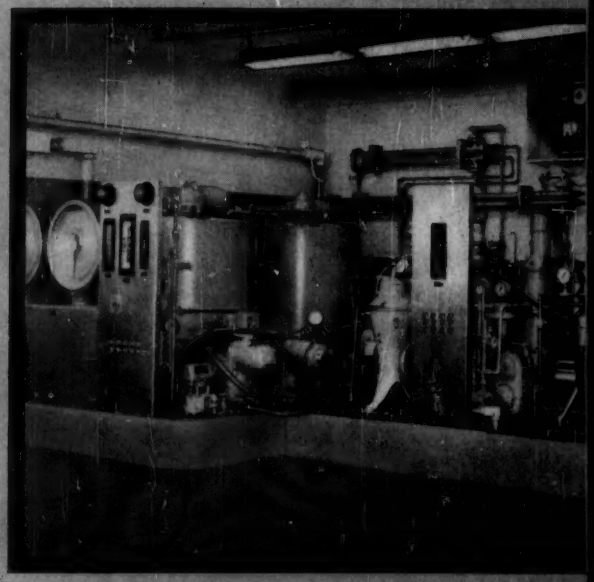
Now your expansion or modernization plans need not be crippled by the current long deliveries prevalent in the instrument industry. Take advantage of the exclusive design features of these Taylor miniature recorders and be on stream up to 6 weeks sooner than otherwise possible.

How is this possible? The same features that enable us to ship the housings early permit our Production Department to build up a reserve stock of separate housings and built-in manifolds. Two shifts daily, including Saturdays, assure fulfilment of this delivery schedule.

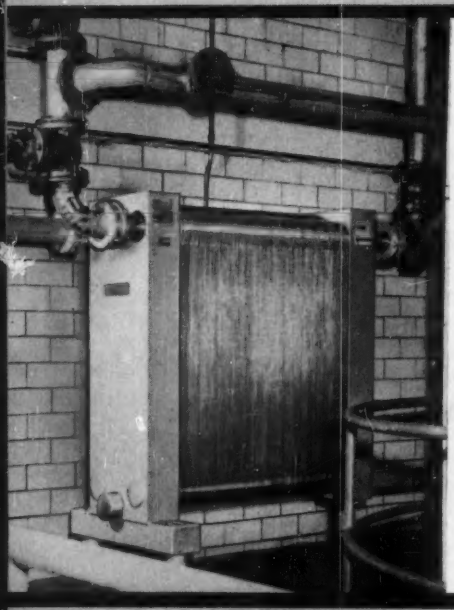
Call your Taylor Field Engineer for the complete story on the TRANSCOPE line—the hottest instruments on the market today! Or write for **Bulletins 98286** (pneumatic), and **98335** (electronic). Taylor Instrument Companies, Rochester, N. Y., or Toronto, Ont.

MEAN ACCURACY FIRST

De Laval tackles process problems



...economically!



How much do your Btu's cost?...and cost!

Your loss every time a pound of product stream cools 1°F is the cost of putting one Btu *into* the process. Multiplied by yearly stream weight and total temperature drop, this usually becomes a hefty figure.

Where conventional heat exchangers have been considered and found wanting, De Laval Plate Heat Exchangers may do the job of reclaiming this costly energy loss. Here's why:

- Stainless steel construction solves almost all corrosion problems – or assures sanitary operation.
- Extremely high heat-transfer efficiency and the compact packing of the corrugated heat-transfer plates means that a very small unit can do the job in very limited space. Wall-mounted De Laval PHE's even eliminate floor space requirements.
- Cleaning is unusually easy. Where the polished steel construction and induced turbulent flow don't eliminate cleaning, the plates are opened for inspection and scrubbing by a simple release mechanism.

Whether it's sulfite liquor, orange juice, latex, honey, detergent, milk, slurry, beer – or what have you – there's some real Btu money to be saved with a De Laval Plate Heat Exchanger. Write for details.

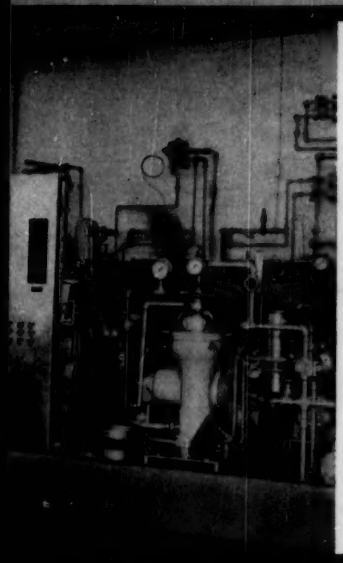
For Further Information Write To Dept. C-7

DE LAVAL

THE DE LAVAL SEPARATOR COMPANY
Poughkeepsie, New York
5724 N. Pulaski, Chicago 46, Illinois

DE LAVAL PACIFIC COMPANY, Dept.
201 E. Millbrae Avenue, Millbrae, Calif.

CENTRIFUGES
PLATE HEAT EXCHANGERS
VIBRATING SCREENS
COMPLETE PROCESSES



On your samples or production quantities . . .

. . . we can perform trial centrifugal separations. Not only do we determine the most practical method, but we also obtain operating data useful for process design and operation. The De Laval pilot plant is equipped with the mixing, heating and reaction equipment necessary to do a comprehensive pilot plant evaluation. Your separation problem is sensibly related to your entire process.

Available is a wide working range of pressure, temperature and flow rate. De Laval engineers who are intimately familiar with the full potential of this well-equipped pilot plant will work with you – and work on your process problem. You benefit from their experience – and from the knowledge that any De Laval separator that is recommended incorporates (75) years of manufacturing know-how.

Give De Laval a crack at your current problems – or let us review some of those that you have uneasily considered "solved."

THE FIRST 75 YEARS ARE THE HARDEST!

"Just 25 years ago – on our 50th anniversary – we might have thought that by this time we had solved every processing problem. Not so, of course. Every year brings new challenges and today we are developing, and making practical, new processes which were considered 'impossible' a quarter century ago. This work usually initiates in our well equipped pilot plant discussed above. In it, our 75 years of experience are at your disposal."

Fred Wheelwright, Industrial Sales Manager

Shakes the product . . . not the plant!

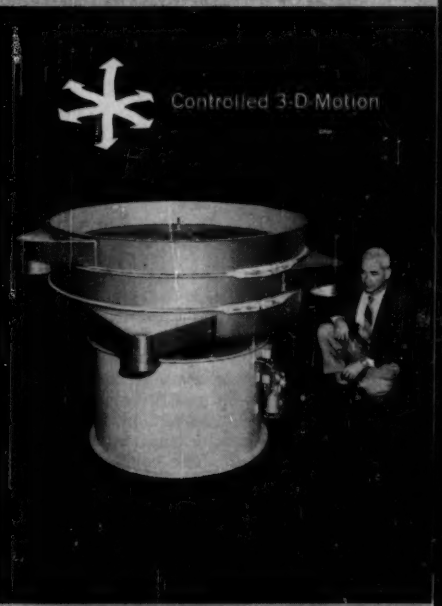
It sits on the floor, but directs its motion to the screens and the product – *not* to your floor beams. Abrasive crystals, soft foodstuffs, dry granules or liquid slurries are all efficiently screened or classified by De Laval's smooth-operating Syncro-Matic screen separator.

The secret is *direct* drive that can be easily adjusted independently for frequency and amplitude. This gives a controllable motion ranging from gentle classification of soft materials to turbulent high-throughput classification of, for example, mineral powders. The action is so efficient that a one horsepower motor does the job. Another great advantage is that the direct mechanical linkage assures a constant classifying action that, unlike gyratory types, does not dampen with heavy screen loading.

Some applications are:

- Wet-mill removal of starch from corn fibers.
- Dry grading of sugar crystals.
- Removal of pollution solids from waste streams.
- Scalping of liquid suspensions prior to centrifugal separation.
- Thickening of wood pulp slurry.
- Classification of resin molding powders.
- Removal of spent grain in fermentation.

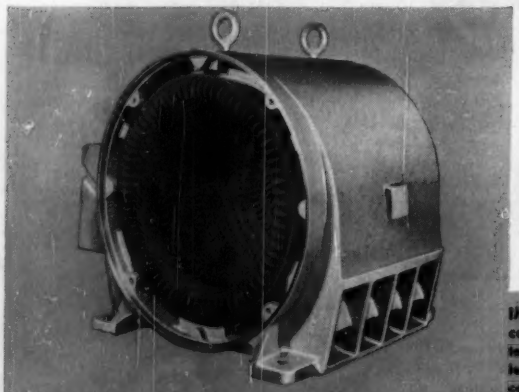
The De Laval Syncro-Matic offers single, double or triple decks of plain or composite screens in a full range of commercial meshes and materials. Let us send you data.



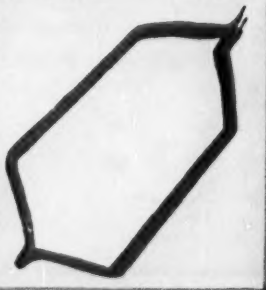
UNEXCELLED PROTECTION

for vulnerable motor coils

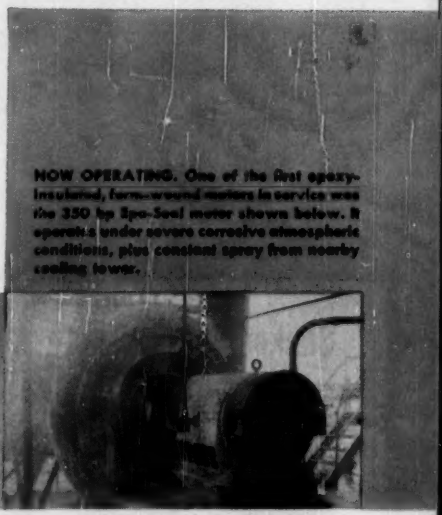
FOR INTEGRAL H. P. MOTORS WITH FORM-WOUND COILS



WOUND STATOR—Core and frame are dipped in EPA-SEAL epoxy resin and baked before winding. Slot coils are epoxy-glass, and all connections are taped with epoxy-mica and glass tape. After winding, the entire stator is given the EPA-SEAL vacuum-pressure process described below.



IMPREGNATED COIL—Finished coil is entirely covered with glass tape before impregnation. Where leads leave the coil, special epoxy compound seals against entrance of moisture. The entire slot section is protected by epoxy-mica wrapper.



NOW OPERATING. One of the first epoxy-insulated, form-wound motors in service was the 350 hp Epa-Seal motor shown below. It operates under severe corrosive atmospheric conditions, plus constant spray from nearby cooling tower.

The Elliott EPA-SEAL epoxy insulation system for integral hp motors includes the application of epoxy resins to all vulnerable parts, and a unique process of vacuum preconditioning and pressure impregnation. Vacuum preconditioning is accomplished by placing wound stators in a tank which is sealed and evacuated. This removes all air and moisture from within the coils and coil slots.

Then while still under vacuum, impregnation is accomplished by pumping special epoxy resin into the sealed tank under pressure. The combined vacuum and pressure treatment assures deep penetration of the resin into the innermost spaces of the coils and coil slots. The result is a tough, impervious, resilient, void-free protection against salt water, acids, alkalis, solvents, cutting oils, carbon-black, abrasives. This exclusive Elliott C-W insulation withstands heat, cold, vibration, resists chipping and cracking, takes cold shock and thermal cycling unharmed. EPA-SEAL epoxy-insulated motor stators with form-wound coils have been completely submerged in water for three months without impairment of insulation resistance or dielectric strength.

WO-1

Elliott's tough, resilient

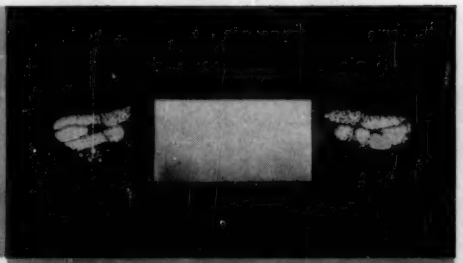
EPA-SEAL

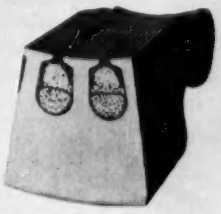
epoxy insulation system

FOR INTEGRAL H. P. MOTORS WITH RANDOM-WOUND COILS

ENCAPSULATED STATOR—Entire wound stator is encapsulated in EPA-SEAL epoxy resin by vacuum-pressure impregnation. Epoxy resin fills slots completely, penetrates coils. Protects laminations, too.

Note in sectioned stator core below how EPA-SEAL completely fills the slots. All conductors are completely encased by this unique epoxy insulation system.





NO VOIDS—Vacuum preconditioning and pressure impregnation assure void-free insulation. Phase insulation is entrapped in the epoxy resin, which even penetrates into lead sleeving. Note how EPA-SEAL bonds to the stator core, seals against moisture. Relatively thin build-up over coils permits rapid dissipation of heat from conductors.

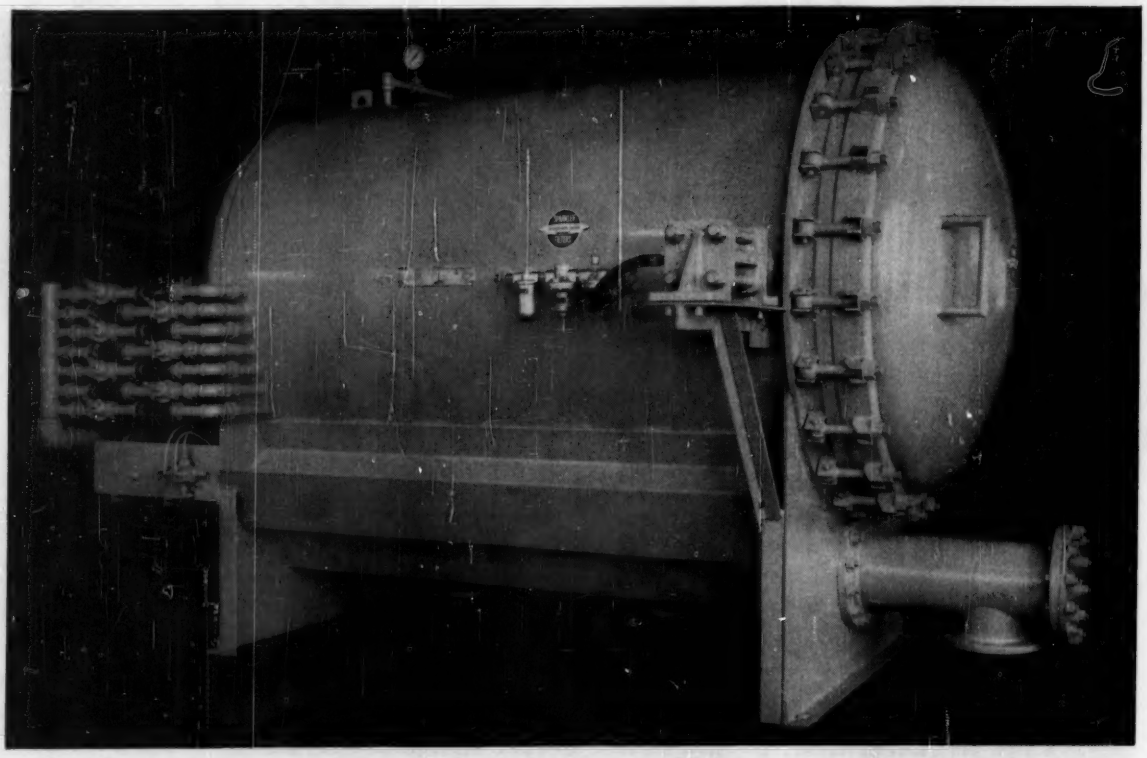
For motors with random-wound coils, the method customarily used for encapsulating consists of applying an external coating over exposed coil ends. But with the Elliott EPA-SEAL system, the entire wound stator is encapsulated in EPA-SEAL epoxy resin by vacuum-pressure impregnation. In addition, stator and rotor laminations are treated with a special anti-corrosive epoxy coating. All hardware is protected by a corrosion-resistant treatment. Weatherproof conduit boxes are standard. Motors are adaptable to NEMA Type I weather protection. Epa-Seal random-wound motors have run while completely submerged in water for more than 1000 hours, without failure.

Elliott Epa-Seal motors are ideally suited for service in chemical and petrochemical plants, paper mills, rubber mills, in deep mines or coastal service—wherever moisture or corrosive atmospheres demand superior motor insulation.

WRITE FOR **New Bulletin PB 6000-12, giving further details on the remarkable EPA-SEAL insulation system. Crocker-Wheeler Plant, Elliott Company, Jeannette, Pa.**

ELLIOTT Company

CROCKER-WHEELER PLANT • JEANNETTE, PA.



A NEW AUTOMATIC FILTER

Has horizontal plate cake stability plus automatic cake discharge

SPARKLER Model HRC

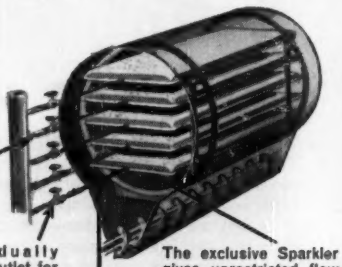
Filters with plates in horizontal position thus assuring complete cake stability, no danger of cake cracking or breakthrough under any operating condition or even with complete shut down.

To clean; cake is blown dry. Each plate operating with individually valved outlets and sight glass. Then plates are rotated to vertical position and the cake drops off with the aid of a vibrator and is expelled by a worm screw in the bottom of the tank in semi dry state or can be furnished without screw for liquid slurry discharge. The complete cleaning operation is performed without opening the filter, a completely enclosed system.

All operations of the filter including precoating and cleaning can be fully automated.

Write for complete information

Diagram of operating position of plates during precoating, filtering, and blow down. Horizontal position assures positive cake stability.



Sight glass for each plate is provided on outlet to give a continuous check on clarity during filtering and to determine when cake is dry during blow down.

Individually valved outlet for each plate.

The exclusive Sparkler plate construction gives unrestricted flow through the filter plate. Uniform, full support of the filter media eliminates mechanical breakage.

Flexible non-corrodible tube connecting each plate with individual outlet. Flexibility of this connection permits rotating of the plate assembly for cleaning.

Diagram of operating position of plates during cleaning, with plates rotated to a vertical position.

Dry cake falls off vertical position of plates and drops into trough bottom to be expelled with screw conveyor.

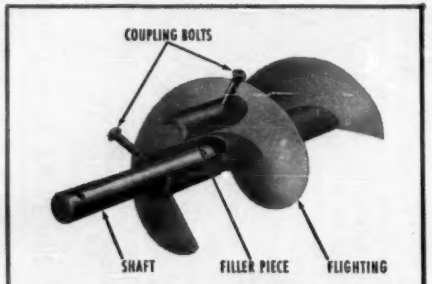
Vibrator rod connects through tank wall with linkage on plates to drop cake.

SPARKLER FILTERS

SPARKLER MANUFACTURING COMPANY · Conroe, Texas, U.S.A.

How Quik-Link conveyor screws

KNOCK DOWN DOWNTIME



HOW IT WORKS — First, coupling bolts and filler pieces are removed from each end of screw section to be replaced. Then the hanger is unbolted, and entire section lifted from trough.

Only LINK-BELT Quik-Link lets you remove a single section without disturbing other components

Here's how you can side-step a serious production bottleneck. Quik-Link offers the fastest method yet of replacing a damaged screw and putting the conveyor back into service. Just a fraction of the normal time.

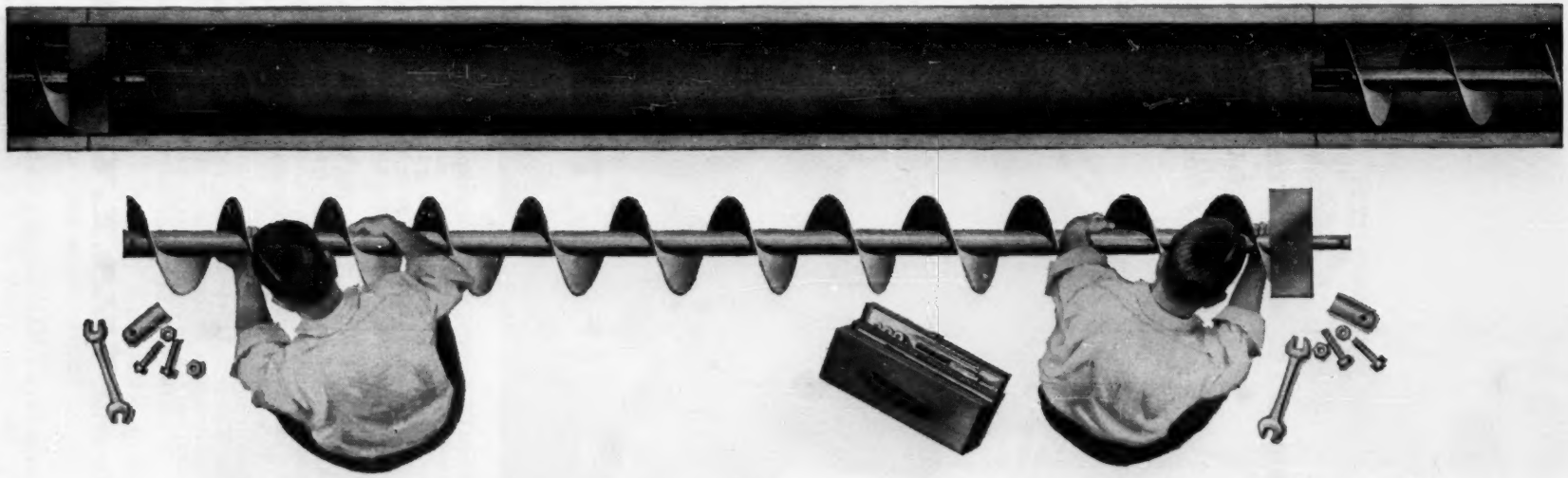
That's why it's time you investigated the "down-time insurance" built into every section of Link-Belt Quik-Link conveyor screws. Your maintenance men become quick-change artists in no time—a wrench and 30 minutes change the damaged screw section and put the conveyor back to work. What's more, there is no need to pull down the entire line . . . no need to disturb other conveyor components.

Quik-Link is just one of a whole group of Link-Belt screw conveyor components that are cutting maintenance and power requirements to the bone. For full facts call your nearest Link-Belt office or authorized stock-carrying distributor. Or write for Book 2989.

LINK-BELT

SCREW CONVEYORS 15,239

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World.



the **WALWORTH CUSTOMER**

looks for specialized durability in

BRONZE, IRON, STEEL, LPV, PLASTIC *and*

PRESSURE-SEAL VALVES

. . . and here's how he gets it

When the Walworth Customer selects valves for special needs in fluid flow control, he insists on knowing that each type will do its job for a long time, with minimum maintenance. In Walworth Bronze Valves, for example, he finds generous wall thickness, and extra-large stems with extra-deep threads.

In Iron Body Gate Valves, the Walworth Customer checks fully open valves for the free flow of fluids. He finds streamlined ports in the Walworth Cast Steel Gate Valves to fight turbulence and pressure drop.

Tight and fast closures are on his mind when he decides on an LPV, and he finds 100% tight closure in the Walworth Lubricated Plug Valve. It is lubricant-sealed against leakage, opens or closes with a quarter turn, and can be serviced under pressure.

To control corrosive fluids the Walworth customer investigates plastic valves and in Walworth PVC Valves and Fittings he finds his answer. For PVC *cannot* corrode. Problems in extreme pressure and temperature lead the Walworth Customer to Pressure Seal valves. He learns that in the Walworth Pressure Seal Cast Steel Valves all pressure containing castings are radiographed to assure their complete soundness.

In his persistent quest for hard facts about materials, workmanship and high quality in the special valves he buys, the Walworth Customer gets his decisive answers in products bearing the Walworth name. If you, too, insist on verifying solid quality for yourself whenever you buy valves, we want you, too, for a Walworth Customer. For the newest literature on any type of Walworth Valves get in touch with your Walworth Distributor.

Or write **WALWORTH** *750 Third Avenue, New York 17, N. Y.*

DISTRIBUTORS IN PRINCIPAL CENTERS THOUGHOUT THE WORLD

WALWORTH SUBSIDIARIES: ALLOY STEEL PRODUCTS CO. • CONOFLOW CORPORATION • GROVE VALVE AND REGULATOR CO
M&H VALVE & FITTINGS CO. • SOUTHWEST FABRICATING & WELDING CO., INC. • WALWORTH COMPANY OF CANADA, LTD.

Foxboro pH Dynalog Recording has an input impedance of 80,000 megohms — eliminates the need for intermediate amplification. Span is adjustable from 2-12 pH; zero, from 0-12 pH.

Foxboro eliminates the amplifier from pH recording and control

cuts the drift, cuts the cost, cuts the maintenance, too!

Foxboro pH Dynalog Controller — for use where it is desired to hold pH at a predetermined value.

Foxboro pH Dynalog Indicator — for use where complete record of pH value is not required.

THAT'S RIGHT — the intermediate amplifier is gone from Foxboro's new low-cost system for measuring pH. And gone with it is the wasted panel space, the drift, the daily standardization inherent with earlier systems.

In the new Foxboro system, the signal from the pH electrode goes direct to a high impedance Dynalog* receiver — without intermediate amplification. Signal operates a direct-reading indicator or recorder—or a controller and alarms, when desired.

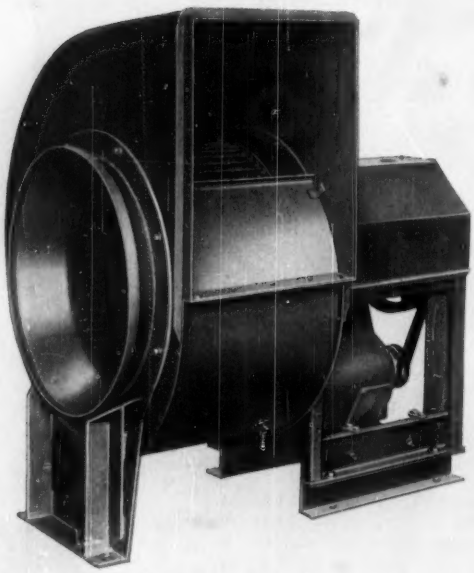
The new Foxboro pH system is the simplest, most economical method of measuring pH available today. Ask your Foxboro Field Engineer to tell you about it. Or write for data sheet. The Foxboro Company, 367 Neponset Avenue, Foxboro, Massachusetts.

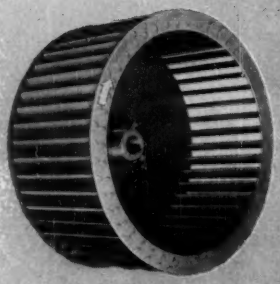
*Reg. U.S. Pat. Off.

FOXBORO
REG. U.S. PAT. OFF.
Analytical Instrumentation

CLARAGE

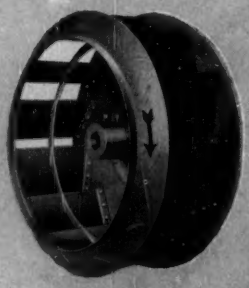
New line of
V-belt driven
Ready Units





LS Ready Units have Low Speed, forward curved blade wheels. These are of the long-recognized Clarage Type HV multiblade design.

or



MS Ready Units have Medium Speed, backward inclined blade wheels with non-overloading horsepower characteristic. These are of the highly regarded Clarage Type NH, Class I design.

Exceptionally sturdy, quiet, ready-to-run fan sets

- for volumes up to 25,000 CFM
- for static pressures thru 2½″
- for clean air up to 300° F.

Distinguishing points — over 15 of them — make these new Clarage units outstanding.
To mention a few: Better motor ventilation . . . entire drive within frame of unit . . . complete accessibility to motor, drive, and bearings. Learn more about the numerous specific advantages that mean greater value to you from Clarage. Request Catalog 517 . . . 36 pages of complete information, selector charts, capacity tables, dimensions.

Clarage Ready Units are ideally suited for supply or exhaust jobs — indoors or outdoors — for buildings of all types, all sizes.

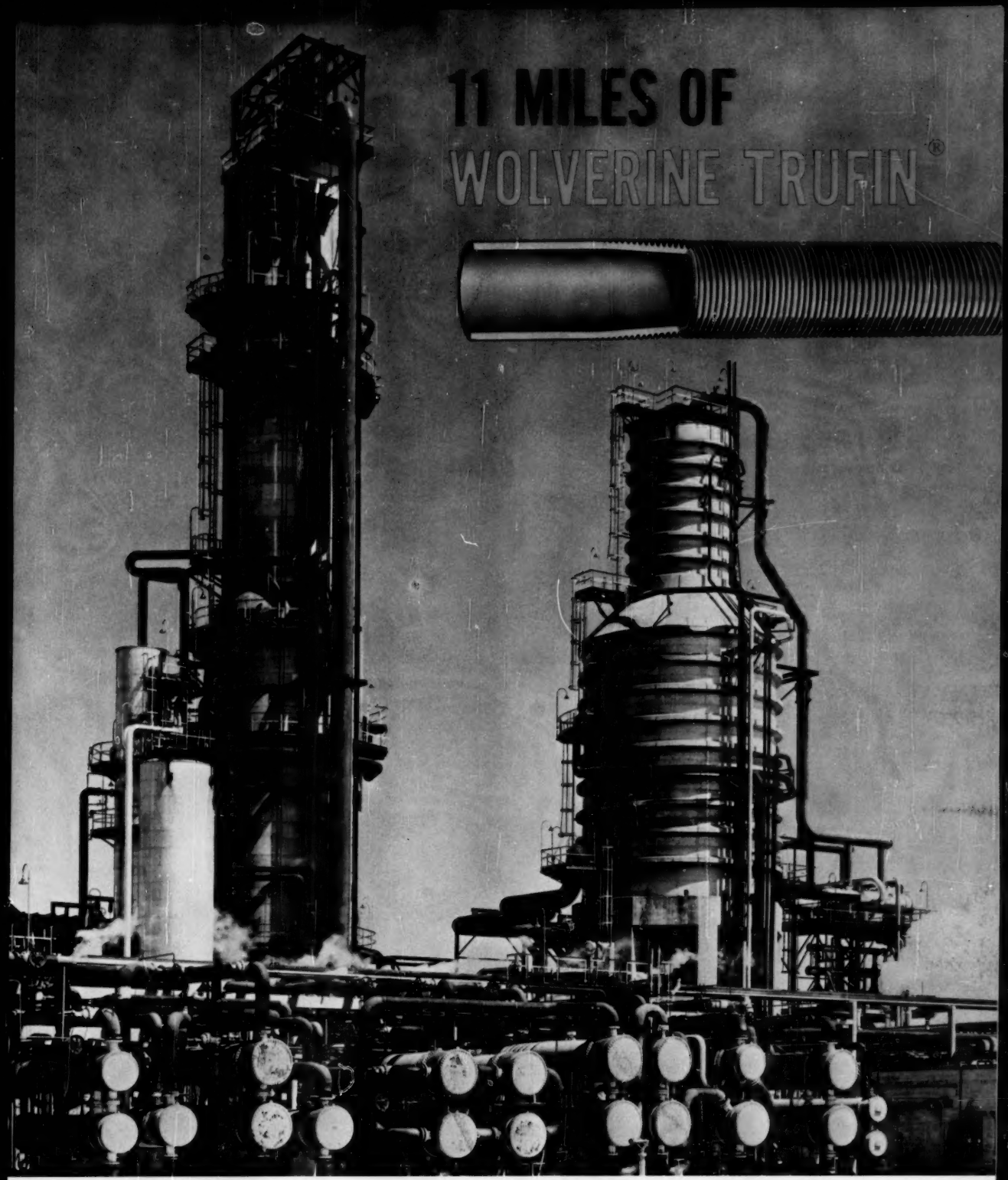
Write for your Copy

Dependable equipment for making air your servant

CLARAGE FAN COMPANY

Kalamazoo, Michigan

SALES ENGINEERING OFFICES IN ALL PRINCIPAL CITIES • IN CANADA: Canada Fans, Ltd., 4285 Richelieu St., Montreal



More than 11 miles of Trufin Type S/T–the integral finned tube–have been used in nine of the shell and tube heat exchangers which are the heart of the world's largest crude oil pipe still. Located in a midwestern refinery, the still is producing 140,000 barrels per day! More than 95% of the Trufin involved is made from Admiralty Brass.

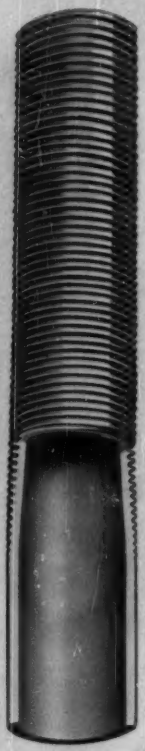
Yes, 11 miles of Trufin is a lot of tube–but just visualize the space savings that Trufin has provided. To perform the same heat duty as Trufin, more than 20 miles of prime surface tube would have had to be used. The advantages are obvious–fewer tubes, fewer shells, much less space required, and more production.

The complete range of finned tube products made by Wolverine Tube is shown on the other side of the page. It's a product line proven by experience.

Write today for more information.

Wolverine Tube manufactures the industry's most complete line of finned tube

PRIME SURFACE TUBE



WOLVERINE TRUFIN TYPE S/T

WOLVERINE TRUFIN TYPE W/H

DUPLEX PRIME SURFACE TUBE

DUPLEX WOLVERINE TRUFIN, TYPE S/T

WOLVERINE TRUFIN TYPE L/C
Bimetal

WOLVERINE TRUFIN TYPE H/R

WOLVERINE TRUFIN TYPE H/A

WOLVERINE TRUFIN TYPE I/L

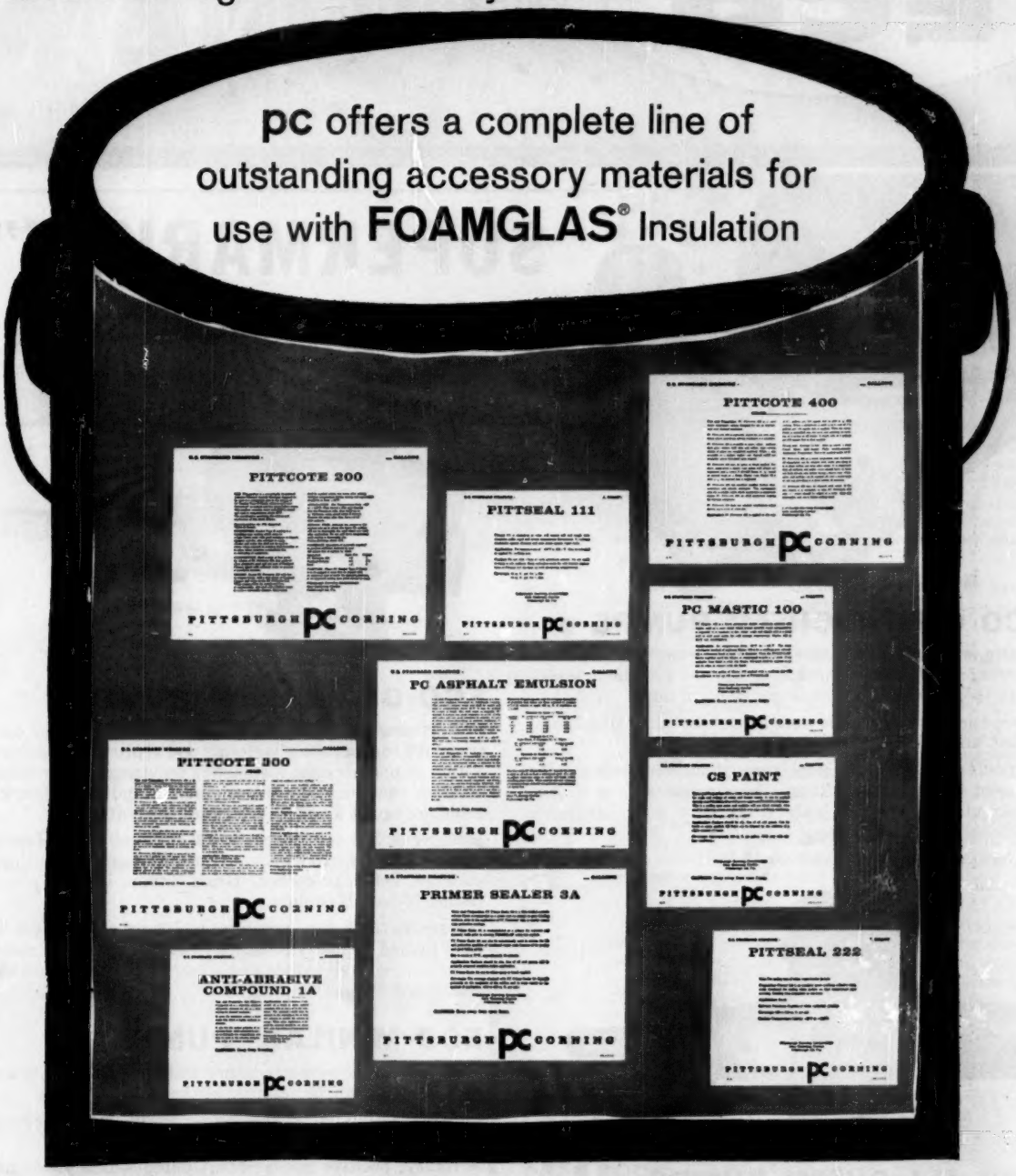
FINNED AND PRIME SURFACE U-BENDS
arranged in a disposable box-type pallet

LET US TELL YOU ABOUT IT

WOLVERINE TUBE
DIVISION OF
Calumet & Hecla, Inc.
DEPT. C, 17232 SOUTHFIELD RD., ALLEN PARK, MICH.
Manufacturers of Quality-Controlled Tubing

PLANTS IN DETROIT, MICHIGAN AND DECATUR, ALABAMA • SALES OFFICES IN PRINCIPAL CITIES

never ruin a good insulation job with inferior accessories...



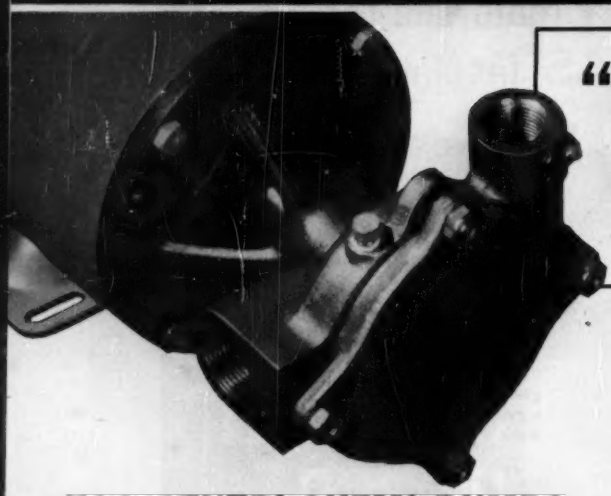
In many installations, the insulation is only as serviceable as the accessory materials used to install it and finish it. That's why Pittsburgh Corning has made available a complete line of insulation accessories specifically designed to insure the natural high performance of FOAMGLAS.

From mastics to finishes to angle pins and lath clips, each accessory has been selected to function perfectly with cellular glass insulation. They assure you the same permanence and satisfaction you always get with FOAMGLAS. Write today for a set of PC Accessory Material Data Sheets; Pittsburgh Corning Corporation, Dept. H-70, address One Gateway Center, Pittsburgh 22, Pennsylvania.

PITTSBURGH pc CORNING

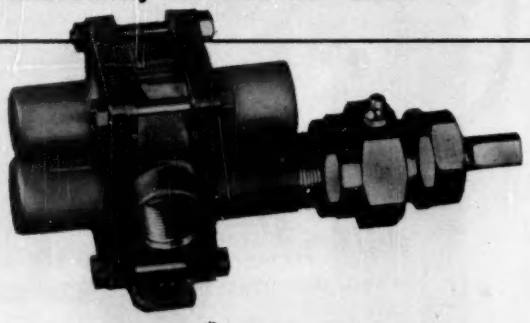
ECO ENGINEERING NEWS

the big name in small pumps for the process industries



"SUPERMARKET" for Small Chemical Pumps

Immediately Available from Stock



ECO CENTRI-CHEM® PUMPS

Widely applicable, corrosion-resistant centrifugal pumps handling most chemicals including slurries with particle size up to 1/16", as well as troublesome sticky fluids.

Offered in 2 types—close coupled motor mounting, illustrated, and ball bearing pedestal mounting.

Carpenter 20 stainless steel throughout. Impellers fully enclosed or semi-open. Rotary mechanical seal is simply constructed and easily maintained with interchangeable components to meet various exposures.

Capacities to 40 gpm. Heads to 57 feet.

ECO ALL-CHEM® PUMPS

Self-priming rotary, positive displacement pumps with twin opposed oscillating impellers providing linear, non-segmented, non-foaming flows ideal for shear sensitive emulsions and safe for auto-detonating fluids. Designed for severe corrosive service.

Housings are 304, 316 and Carpenter 20 stainless steel, Hastelloy* B and C. Bearings and seals are self-lubricating, chemically impervious Teflon†. Impellers of Teflon, phenolic resins, Hypalon†, Nylon, etc.

Capacities to 10 gpm, pressures to 75 psi, viscosities to 900 SSU. Drives are direct electric motor, air motor, pulley, sprocket or variable speed drive.

**Union Carbide Trademark, † du Pont trademarks.*

ECO GEARCHEM® PUMPS

Self-priming gear pump for intermittent or sustained operation with constant flow metering and reproducible accuracy within ± one per cent (depending on viscosities) or maintenance of vacuum in the micron range. Handles all chemicals, acids, oxidants, alkalies, aromatics, solvents.

Housing of 316 and Carpenter 20 stainless steel, Hastelloy B and C, monel, nickel, zirconium and titanium. Bearings of du Pont Teflon or carbon. Gears Teflon, carbon, phenolic resins, Nylon, Hastelloy.

Capacities to 10 gpm, pressures to 100 psi at 1750 rpm with light bodied media. Viscosities to 30,000 SSU with metallic gears and reduced speeds and volumes. Same drives as with ALL-CHEM Pumps.

ECO MINILAB® PUMPS

The ideal all-purpose laboratory and pilot plant units which handle severe corrosives around the clock.

Capacities from 0 to 2 gpm, pressures to 100 psi. Reversible and self-priming.

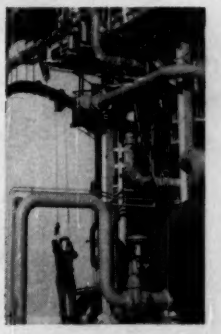
A rotary, positive displacement pump which yields linear flow best suited for constant flow metering.

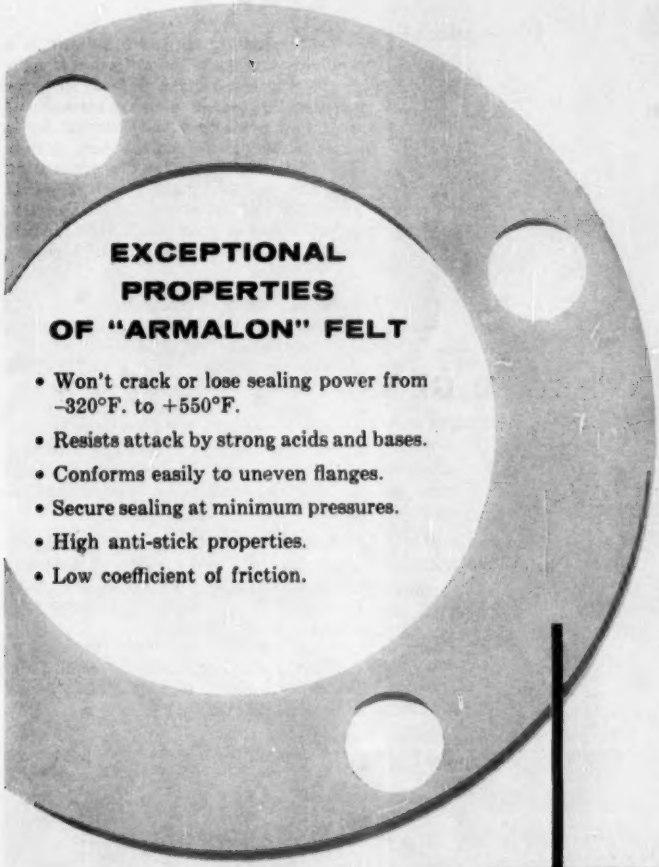
Hastelloy C and Teflon construction. Self-lubricating, non-contaminating, Teflon bearings and seals.

• Write for Literature on Complete Eco Pump Line, the mass-produced standard precision pumps which are always available for immediate delivery from stock.

ECO ENGINEERING COMPANY • 12 New York Avenue • NEWARK 1, N.J.

Gaskets exposed to harsh chemicals, extreme temperatures demand the remarkable resistance properties of Armalon® felt





EXCEPTIONAL PROPERTIES OF "ARMALON" FELT

- Won't crack or lose sealing power from –320°F. to +550°F.
- Resists attack by strong acids and bases.
- Conforms easily to uneven flanges.
- Secure sealing at minimum pressures.
- High anti-stick properties.
- Low coefficient of friction.

If harsh chemicals and –320°F. to +550°F. temperatures force you to replace gaskets every few weeks, you need gaskets made of Du Pont "Armalon"* TFE-fluorocarbon resin-impregnated felt. This unique gasketing material gives months (even years!) longer service, can drastically cut replacement costs and work interruptions.

Just look at these remarkable examples of how "Armalon" felt gaskets extend service life under extreme operating conditions:

Lasts over 700% longer! "Armalon" gaskets handling 99.3% sulfuric acid at 200°C. are still in service after 18 months. Conventional materials frequently had to be replaced within a week.

HNO_3 fumes at 170°C. and 97 psi. were still satisfactorily carried in stainless-steel pipes gasketed with "Armalon" after 7 months. Other materials had to be replaced every 10 to 15 days.

After 15 months, ammonium sulfate and sulfonic acid are still being processed in a centrifuge containing a gasket of "Armalon".* Previous materials were replaced every two to three weeks.

These are just three of the many examples of exceptional performance of "Armalon" illustrated in the Du Pont booklet *"Armalon"—for gasketing under extreme conditions.* Send for your free copy and see how you can end troublesome gasketing problems. Clip coupon or write Du Pont . . . there's no obligation. E. I. du Pont de Nemours & Co. (Inc.), Fabrics Division, Wilmington 98, Delaware.

""Armalon" is Du Pont's registered trademark for its TFE-fluorocarbon-resin-impregnated felts.*

DU PONT INDUSTRIAL COATED FABRICS

DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING THROUGH CHEMISTRY

FREE BOOKLET tells you how you can reduce gasketing costs . . .

E. I. du Pont de Nemours & Co. (Inc.)
Fabrics Division, Dept. CE-07, Wilmington 98, Delaware

Please send me a free copy of *"Armalon"—for gasketing under extreme conditions.*

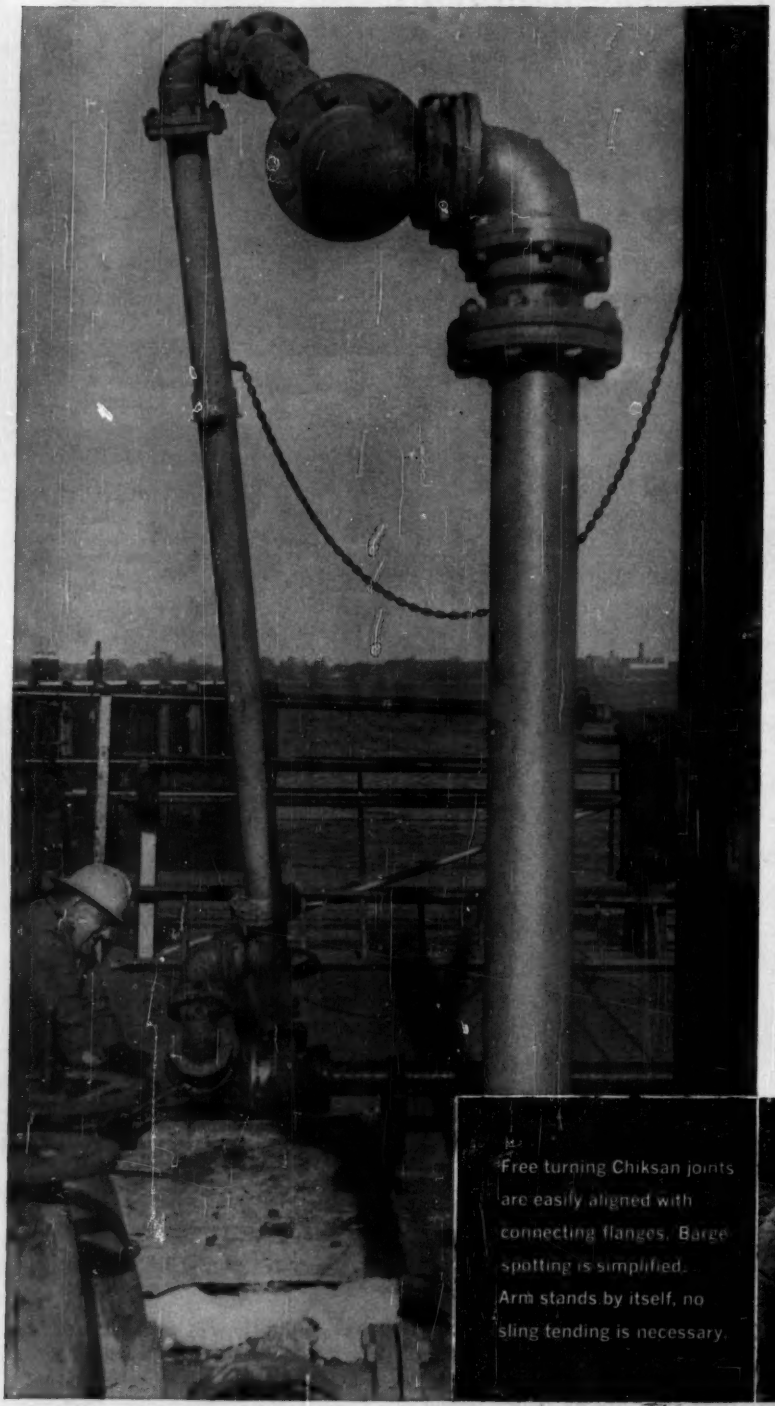
Name_____ Position_____

Company_____

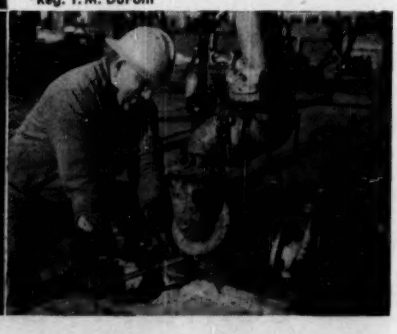
Address_____

City_____ Zone_____ State_____

Speaking of handling corrosives—



Free turning Chiksan joints are easily aligned with connecting flanges. Barge spotting is simplified. Arm stands by itself, no sling tending is necessary.



THIS CHIKSAN LOADING ARM IS HANDLING 41 MILLION POUNDS OF SULFURIC EACH MONTH WITHOUT A LEAK

At best, handling corrosive sulfuric is a problem. And when the situation is compounded by need for a flexible line, the problem can become acute. This was the situation presented to Chiksan by a large chemical plant in the east. A flexible steel loading arm, incorporating new DS Series Chiksan swivel joints provided the solution. Utilizing DuPont's Viton A packings*, this loading arm is used to service barges bringing sulfuric to a processing plant.

As to results, the customer writes: "At the time the photographs were taken, the installation had been in service for six months without acid leaks and the only maintenance required was the normal lubrication of the Chiksan joints. An average of 41,000,000 gross pounds per month of sulfuric acid, 54° Baume, 60° Baume and Oleum was pumped through the installation during the six-month period."

Chiksan's DS Series swivel joints, developed especially for chemical, steam and hot gas service, are but one of the many swivel joints you can apply to solve your flexible line problems. There's a close-by Chiksan Field Representative ready to analyze your requirements and make recommendations. Write Chiksan today for his name and copy of our catalog.

*Reg. T. M. DuPont

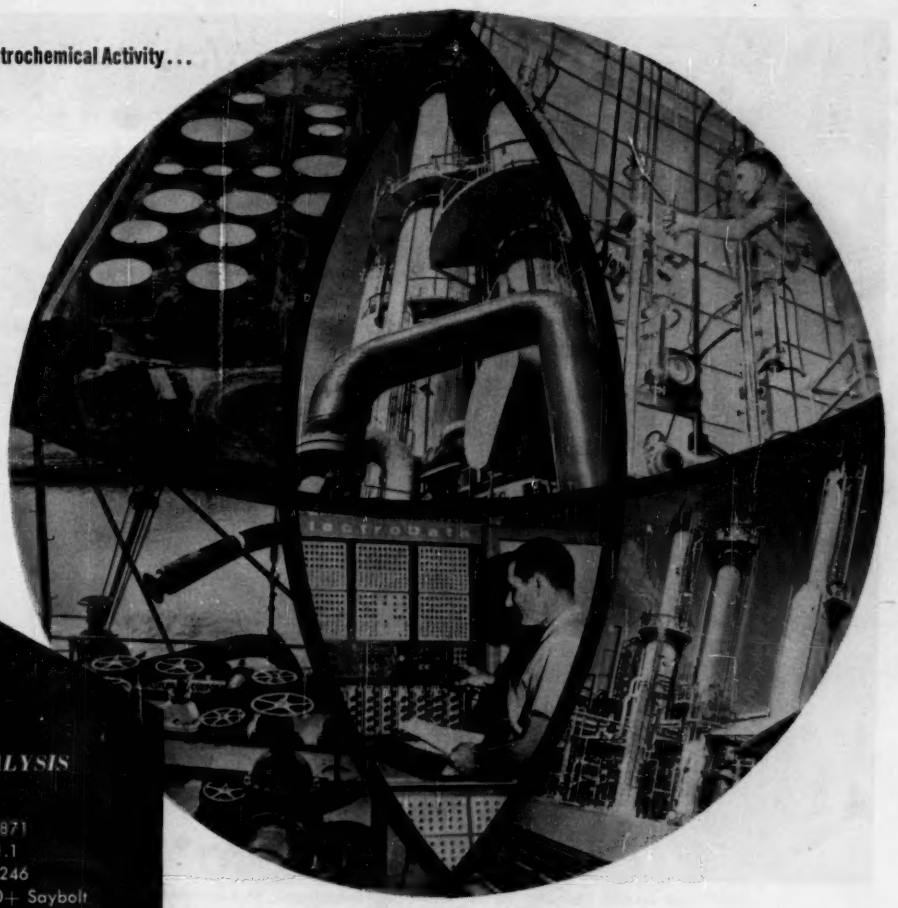
CHIKSAN fmc

A SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION

#60-51

CHIKSAN COMPANY—Brea, California • Chicago 5, Ill. • Newark 2, N. J. • Divisions: Chiksan International, Hamer Valves, Weco • Subsidiary: Chiksan of Canada Ltd.

from the Delhi Sphere of Petrochemical Activity...



TYPICAL ANALYSIS

Sp. Gr. 15.56/15.56°C	0.871	
API Gravity	31.1	
Weight, Lbs/Gal	7.246	
Color	30+ Saybolt	
Acid Wash Color	Less than No. 1 Standard	
Acidity	No free acid	
Sulfur Compounds	No H_2S or SO_2 or Thiophene	
K. B. No. (Toluene-105)	101	
Distillation		
First Drop	138.0°C	280°F
Dry Point	141.0°C	286°F
Flash TCC	82°F	

DELHI 5° XYLENE

...high solvency thru high purity

Strict adherence to rigid process control standards at Delhi-Taylor pays off in purity products. Delhi-Xylene is a case in point. Its purity is evident in its consistently high KB value, indicative also of its high solvency for paints, inks and other products.

You can depend upon the quality and uniformity of Delhi petrochemicals and are assured of efficient and courteous service.

Delhi 5° Xylene, Benzene, Toluene and other petrochemicals are available by barge, tank car or tank truck from our plants and bulk terminals.

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CHEMICAL DIVISION

DELHI-TAYLOR OIL CORPORATION

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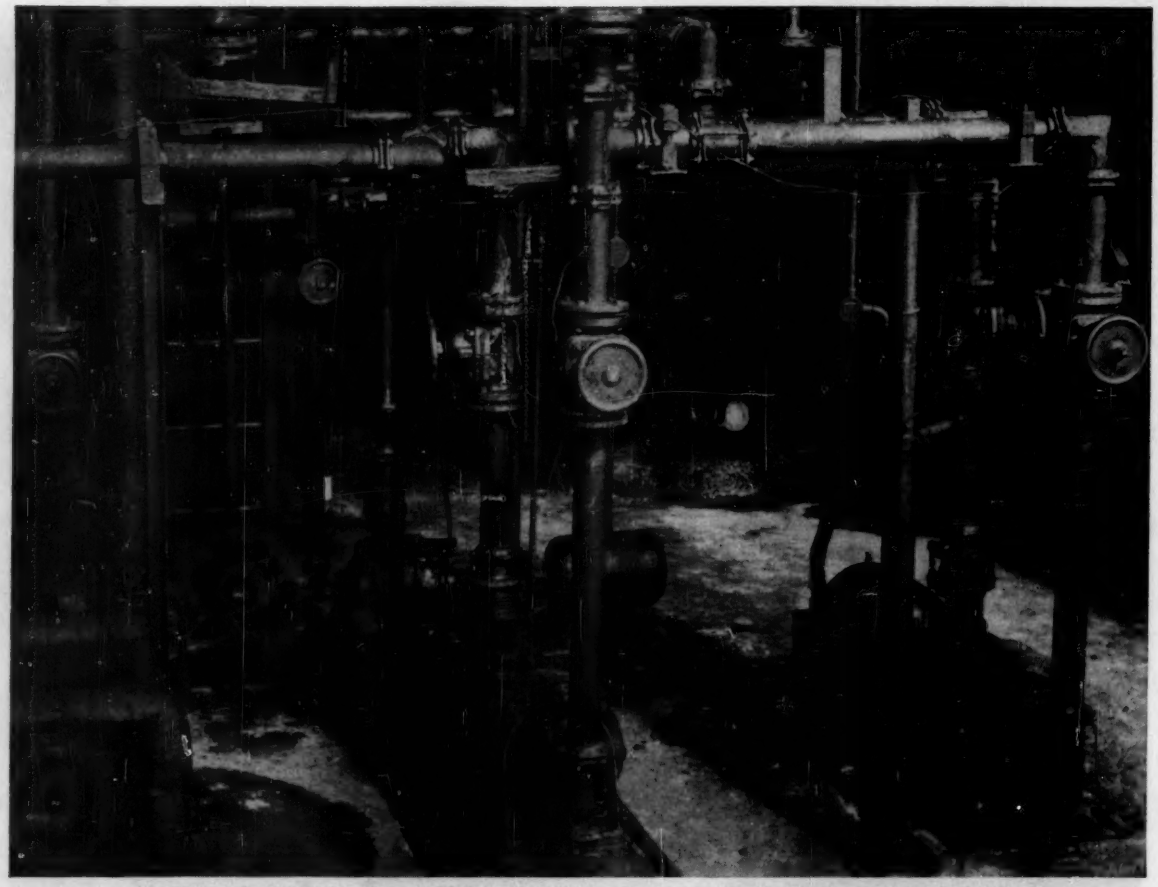


Glass-lined Grinnell-Saunders Valves, with Teflon Diaphragms, on benzene hexachloride lines at Diamond Alkali's Greens Bayou, Texas, plant. Hundreds of other Grinnell Diaphragm Valves are used in other areas of the plant.

How a manufacturer of benzene hexachloride solved a serious valve leakage problem

Valving at Diamond Alkali's Greens Bayou, Texas, plant had become expensive. Leakage of a product containing 30% to 40% benzene and free chlorine released fumes and caused rapid corrosion of the metal parts of the valves used previously, as well as of adjacent equipment.

This problem was corrected when Grinnell-Saunders Diaphragm Valves were used. The first replacement of any part of the Grinnell Valves did not occur for two years, and this was the diaphragm *only*. The former valves had to be *completely* replaced every one to two months! Bodies of the Grinnell valves lasted four years. In short, when Grinnell-Saunders Diaphragm Valves were installed, stem leaks ceased; corrosion was eliminated; and downtime to install new valves was practically ended.

For further facts about Grinnell-Saunders Valves, see Grinnell's insert in Chemical Engineering Catalog, or Sweet's Plant Engineering File — or write directly to Grinnell Company, Providence 1, Rhode Island.

- Diaphragm lifts high for streamline flow in either direction
- Diaphragm presses tightly to effect positive closure
- No packing glands to need attention
- Diaphragm easily replaced without removing valve body from the line
- Wide choice of body, lining and diaphragm materials

GRINNELL-SAUNDERS DIAPHRAGM VALVES

GRINNELL COMPANY, PROVIDENCE 1, R. I. • BRANCH WAREHOUSES AND DISTRIBUTORS FROM COAST TO COAST
PIPE FITTINGS • VALVES • PIPE HANGERS • PREFABRICATED PIPING • UNIT HEATERS • PIPING SPECIALTIES

New!

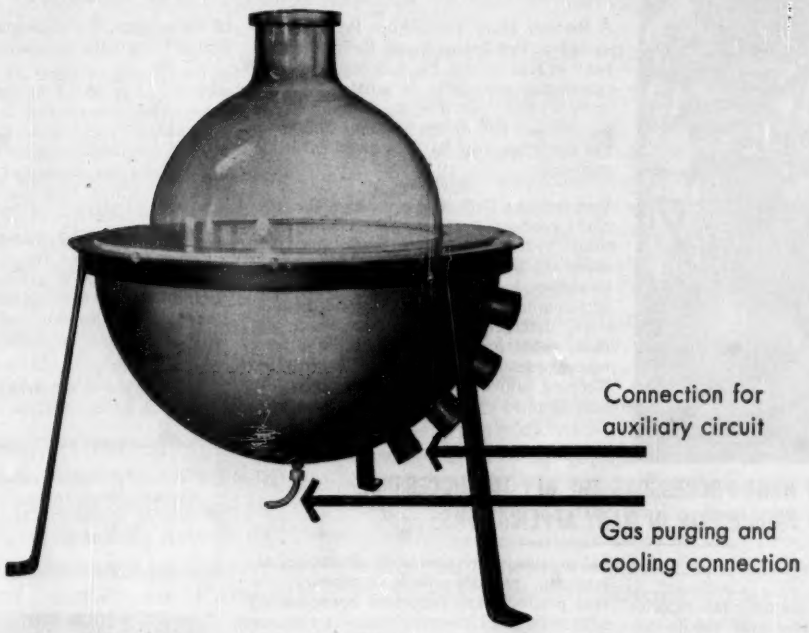
...the series U

Here's the ultimate in safety and control for distillation and fractionation processes . . .

Glas-Col Heating Mantle

. . . with small auxiliary circuit to supply vaporization heat for high-boiling residues*

. . . with special connections for gas purging and cooling**



AUXILIARY CIRCUIT: Each Glas-Col Series U Heating Mantle includes a small auxiliary circuit at the bottom, center.

When a small amount of high-boiling residue remains in the flask, this circuit can be used to furnish the heat of vaporization . . . while the upper circuits are turned off or operated at reduced heat input. This prevents superheating of the bare wall of the flask above the liquid level, and thus eliminates damage to flask, damage to heat-sensitive chemicals, and superheating of vapors before they reach the column.

At the beginning of a fractionation, when the flask is full of liquid, the upper circuits can be adjusted so input is just INSUFFICIENT to maintain the desired rate of flux. THEN the small auxiliary circuit can be cut in and out to obtain the desired reflux rate.

GAS PURGING AND COOLING CONNECTION: Fire hazards are eliminated because heating elements can be continuously blanketed by a slow stream of inert gas such as nitrogen, which is bled in through a special connection.

And cooling can also be accomplished by passing air into the special connection and through the mantle housing.

Sizes and Prices: *Glas-Col Series U Mantles are available for flask sizes ranging from 1 liter through 22 liters. Made with quartz fabrics, Series U Mantles are designed to operate at temperatures to 6[illegible]°C. Prices range from* $34.00 to $144.00.

Safety and control to the last drop!

GLAS-COL Electric Heating Mantles

*U. S. Patent No. 2,739,220 **U. S. Patent No. 2,739,221

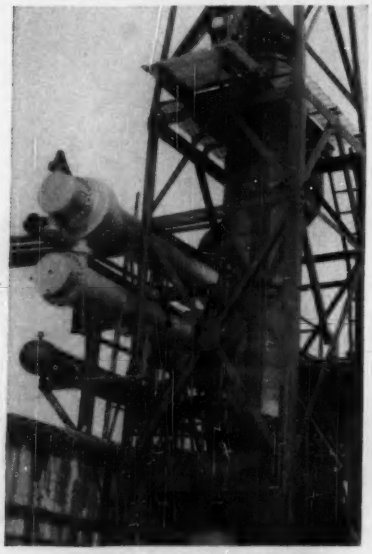
Glas-Col Apparatus Co., Inc.
Dept. CR
711 Hulman Street
Terre Haute, Indiana

New Bulletin! *For more detailed information, ask for Bulletin 4-D*

RODNEY HUNT

FLUID PROCESSING

RODNEY HUNT MACHINE CO., Process Equipment Division, 10 VALE STREET, ORANGE, MASS



TURBA-FILM® PROCESSOR CONVERTS BATCH OPERATION TO CONTINUOUS PROCESSING

A Rodney Hunt Turba-Film Processor installed at the Pennsylvania Refining Company in Karns City, Pa., has made possible continuous processing in what was previously a batch operation. The single processing unit occupies only about one-quarter of the space taken up by the equipment it has replaced.

Pennsylvania Refining Company makes specialty products such as sulfonates, petrolatums, hydraulic oils, etc. under the trade name PENN DRAKE. The Turba-Film Processor is used in the manufacture of petroleum sulfonates used in motor oil additives, detergents, rust preventatives, and many other products. It was selected after intensive testing conducted at Pennsylvania Refining utilizing a Turba-Film laboratory unit supplied by Rodney Hunt. On the basis of these tests, the decision was made to change from batch to continuous processing.

In the refining of white oil, alcohol diluted with water is added to extract the sulfonates. After the solution is drawn off, the Turba-Film Processor distills the water and alcohol from the sulfonate. The vapors are drawn into the condenser section of the processor where they are condensed and reclaimed.

The Turba-Film Processor operates 24 hours a day at the rate of 10 gallons of solution per minute – 14,400 gallons per day. The equipment has been operating efficiently since last fall with only such minimal maintenance as proper lubrication.

At present the processor is operated manually, but a complete system of automatic controls is being ordered.

For information about how the Rodney Hunt Turba-Film Processor may be applicable to your process, write for Bulletin 117.

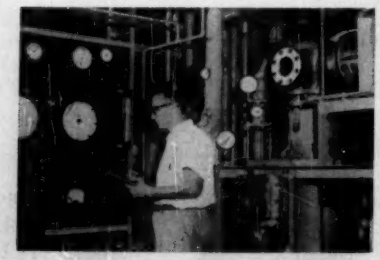
RODNEY HUNT PROCESSORS THE KEY TO SUCCESSFUL PRODUCTION IN MANY APPLICATIONS

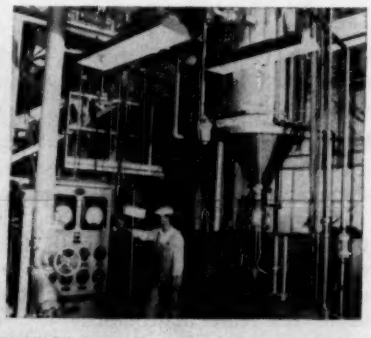
IN CHEMICALS...

In the biological and chemical laboratories of a New Jersey manufacturer, the Turba-Film Processor is extensively used to concentrate products coming from extraction or ion exchange columns. Formerly a batch process, the Turba-Film unit now makes this a continuous operation. In addition to eliminating three vats required by the original process, other operating advantages are reported: product quality is superior; several products are processed consecutively with only brief cleaning periods; evaporation takes place below 90°F., preventing degradation of heat-sensitive antibiotics; capacity is increased, speeding output; and with complete Rodney Hunt instrumentation, the unit requires a minimum of attention and manpower.

IN PHARMACEUTICALS...

A manufacturer of pharmaceuticals encountered product discoloration and loss of product prior to placing a bacteria-killing drug into full production. This problem was solved by replacing conventional evaporator with a Rodney Hunt Turba-Film Processor designed to handle the heat-sensitive product. The Turba-Film Processor helps turn out a uniform top-quality pharmaceutical product.





IN FOOD...

This Turba-Film Processor produces superior quality fruit concentrates at a rate of 5 tons per hour in a packing plant on the West Coast. Operating 24 hours a day during the peak season, the processor maintains an excellent operating record with a minimum of maintenance.

The taste and quality of the concentrates produced are protected from the injurious effects of overheating because of the precisely controlled, short-time exposure of the product in the thermal section. As with other applications, the Turba-Film Processor consistently and automatically retains the essential properties and desired qualities of the product being processed.

DEVELOPMENTS...

JULY 11, 1960

Chementator

T. PETER FORBATH

Scientific Design reports it has developed process for direct oxidation of benzene to phenol. Route produces no troublesome by-products such as acetone or salt cake, is well suited for use in small, low-cost "package" plants.

Thiokol, General Motors and Linde have teamed up in a nuclear heat-liquid hydrogen rocket project. Firms have set up development center in Parsippany, N. J., to make preliminary design studies.

Ford Motor reportedly is considering using Teflon-type lube-free bearings in steering and front suspension of some of its 1961-model cars. If bearings are adopted, cars would need grease jobs only at 10,000-mile intervals.

Battelle has harnessed fluid-bed processing to job of reducing columbium pentachloride to columbium metal. Bed consists of seed columbium; hydrogen serves as reducing-fluidizing gas at 1,500 F.

Refiners trigger naphthalene upheaval

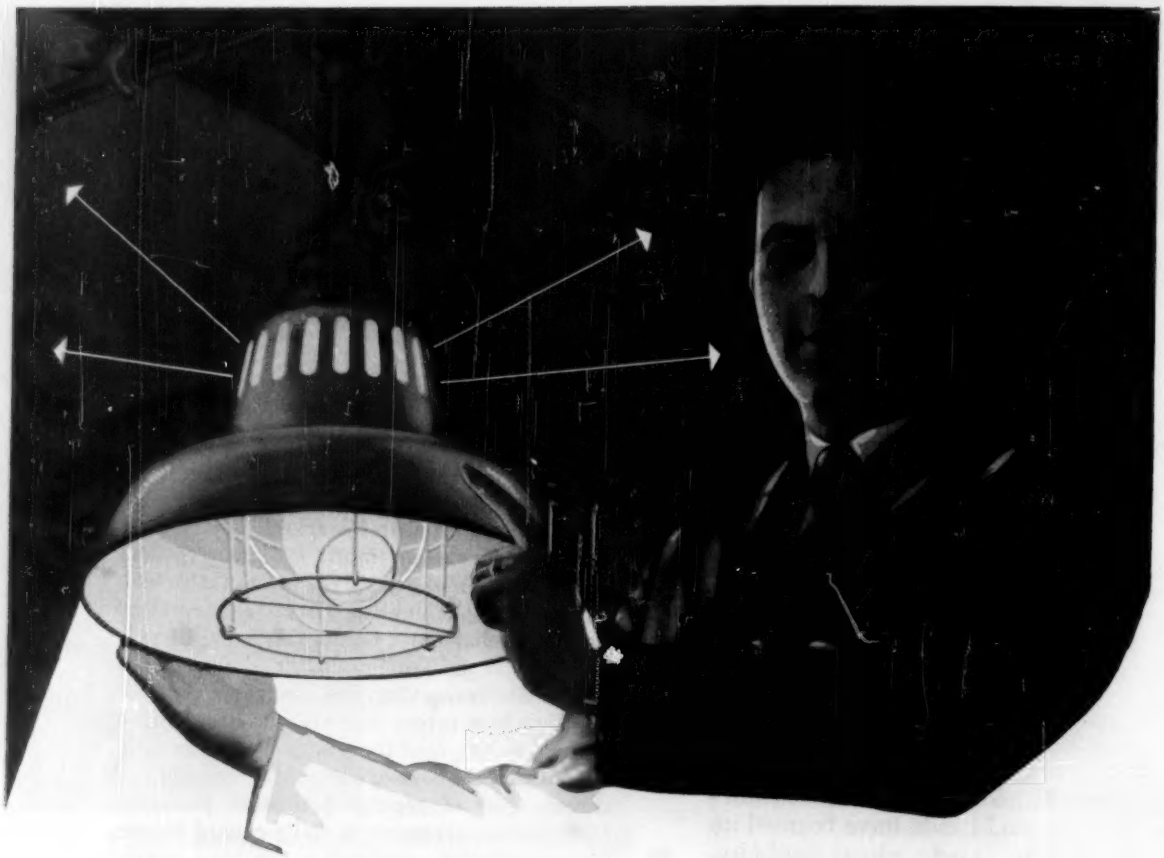
Following lead of Ashland Oil & Refining (*Chementator*, Dec. 14, 1959, p. 69), two more petroleum refiners have headed into the petrochemical naphthalene market, announcing plants due on stream in late 1961. Sun Oil will build a 100-million-lb./yr. facility at its Toledo, Ohio, refinery. Tidewater Oil is teaming with Union Oil subsidiary, Collier Carbon & Chemical, to build a 50-million-lb./yr. unit at Tidewater's Delaware City, Del., refinery.

Two big factors that kicked off rush into petrochemical naphthalene are (1) serious short supply of coke-oven naphthalene and (2) chronic glut of regular petroleum products. Naphthalene shortage, initially caused by the recent extended steel strike, has been aggravated by current low level of steel production. Too, naphthalene imports from Europe have dropped some 100 million lb. from the 1955 high of 123 million lb./yr. because of increasing naphthalene consumption abroad.

Phthalic anhydride producers, major consumers of naphthalene, have been caught in a dwindling-supply-rising-cost vise. (Current naphthalene price is 7-8¢/lb.—when you can get it.) The three new petrochemical naphthalene producers will be able to supply about ⅓ of U.S. needs. And they claim that they have long-term contracts for all they can produce.

Industry observers put price of petrochemical naphthalene at about 6¢/lb., which should cause some price adjustments by coke-chemical producers. Moreover, refiners say their product will be purer than the 78° coal-tar naphthalene which will eliminate the extra refining step required by fluid-bed phthalic producers.

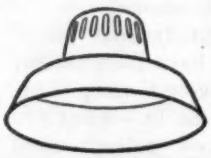
Both Sun and Tidewater will make naphthalene via the catalytic hydrodealkylation of alkyl naphthalenes similar to the Ashland-Universal Oil Products process (*Chementator*, Oct. 19, 1959, p. 98). Sinclair, Atlantic and Mobil Oil are also known to have researched naphthalene processes but these



Now you can get optional

SLOTTED Reflectors

on these Crouse/Hinds Lighting Fixtures



Explosion-proof—Type EV, Dust-ignition-proof—Type DL in slotted dome or angle reflectors.

Vapor-tight, weather resistant types V and VM in slotted dome or angle reflectors.

Reduce fatigue, accidents and worker tension; improve working environments and employee relations. In both original and replacement installations in major plants, the new slotted reflectors—exclusive with Crouse-Hinds—produce the following results:

- Elimination of dark, dungeon-like areas above reflectors
- Elimination of harsh brightness contrast, improving visibility and seeing comfort
- Reduction of fatigue of workers, and accidents due to fatigue
- Increase of production in machine work, assembly and inspection operations
- Reduce fixture operating temperature and worker discomfort from reflected heat, especially with low-hanging fixtures
- Reduced accumulation of dirt and dust, due to improved air circulation through reflectors
- Slotted reflectors are white enamel finish inside and out

FOR COMPLETE INFORMATION on all Crouse-Hinds lighting fixtures equipped with the new slotted reflectors, call your nearest Crouse-Hinds distributor, or write us.

CROUSE HINDS
SYRACUSE NEW YORK

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CROUSE-HINDS COMPANY OF CANADA, LTD., TORONTO, ONT. **CROUSE-HINDS INSTRUMENT COMPANY, INC., SILVER SPRING, MARYLAND**

three deny any commercial plans at the present time. Speculation persists, however, that other refiners will soon jump on the bandwagon. Union Oil, for example, admits it's considering a West Coast plant to serve growing ranks of phthalic producers there.

One-step synthesis of acetic claimed

"A one-step oxidation of a light petroleum fraction directly to acetic acid."

That's how Britain's Distillers Co. describes the route it will follow in its new $5.6-million acetic acid plant to be on stream early in 1962 at Hull, England. Facility will be supplied with raw material by the petrochemical plant at Grangemouth, Scotland, jointly owned by Distillers and British Petroleum.

Details of Distillers' new process are virtually nonexistent at this time. But just the bare statement that it's a single-stage operation feeding on a petroleum fraction has been enough to set the experts buzzing with speculation and puzzlement.

Certainly one reason for this reaction is the radical departure in choice of raw material that Distillers, one of Britain's and the world's major producers of acetic acid, has made. For the last decade, company has been producing acetic by dehydrogenation of ethyl alcohol to acetaldehyde followed by oxidation of acetaldehyde to acetic. (Prior to that Distillers made acetic via the fermentation of molasses.) Ethanol-based processes are currently the most widely used routes to acetic. Runners-up are similar two-step processes starting with acetylene or butane.

Exactly what Distillers' feed now will be is far from clear. But industry observers tend to translate "a light petroleum fraction" to mean a naphtha-type material, possibly gasoline. No present acetic maker is known to use such a raw material. Closest anyone comes to it is Celanese which produces acetic at Pampa, Tex., from butane. But, interestingly, Celanese has a patent on a process for making the acid via the oxidation of gasoline.

But whatever the feed, synthetic acetic has always been made by a two-step process—the first to produce acetaldehyde, the second to oxidize the aldehyde to acid. Thus Distillers' claim that it can go straight from its feed to acetic in one oxidation step has served to further whet the experts' curiosities. All Distillers will say, however, is that its process represents a considerable technical advance.

Rotating-tray still seeks U. S. jobs

A European-design fractionation tower that boasts a pressure drop of only 1 mm. Hg may soon make its American debut. Vulcan-Cincinnati, licensed by Stora Kopparbergs Bergslag (Falun, Sweden) to build and sell the Stora-patented tower in the Western Hemisphere, has launched on a joint program with a U.S. chemical firm to gather operating data for an unidentified distillation application.

Stora's tower departs radically from the usual bubble-cap or packed-column design. It achieves vapor-liquid contact via a series of rotating trays which fling liquid reflux droplets from column center to wall. Rising vapor, passing through this liquid curtain, contacts liquid intimately just as it would on conventional trays. Liquid that reaches tower wall is directed back to rotor base for recirculation.

There are two advantages claimed for this design. Open cross-sectional area in rotating-tray tower is 20-40% as against 12-15% common in bubble-cap columns. And energy needed for vapor-liquid contact in Stora's design is provided mechanically instead of by vapor bubbling through liquid from tray to tray, thus markedly slashing pressure drop through column.

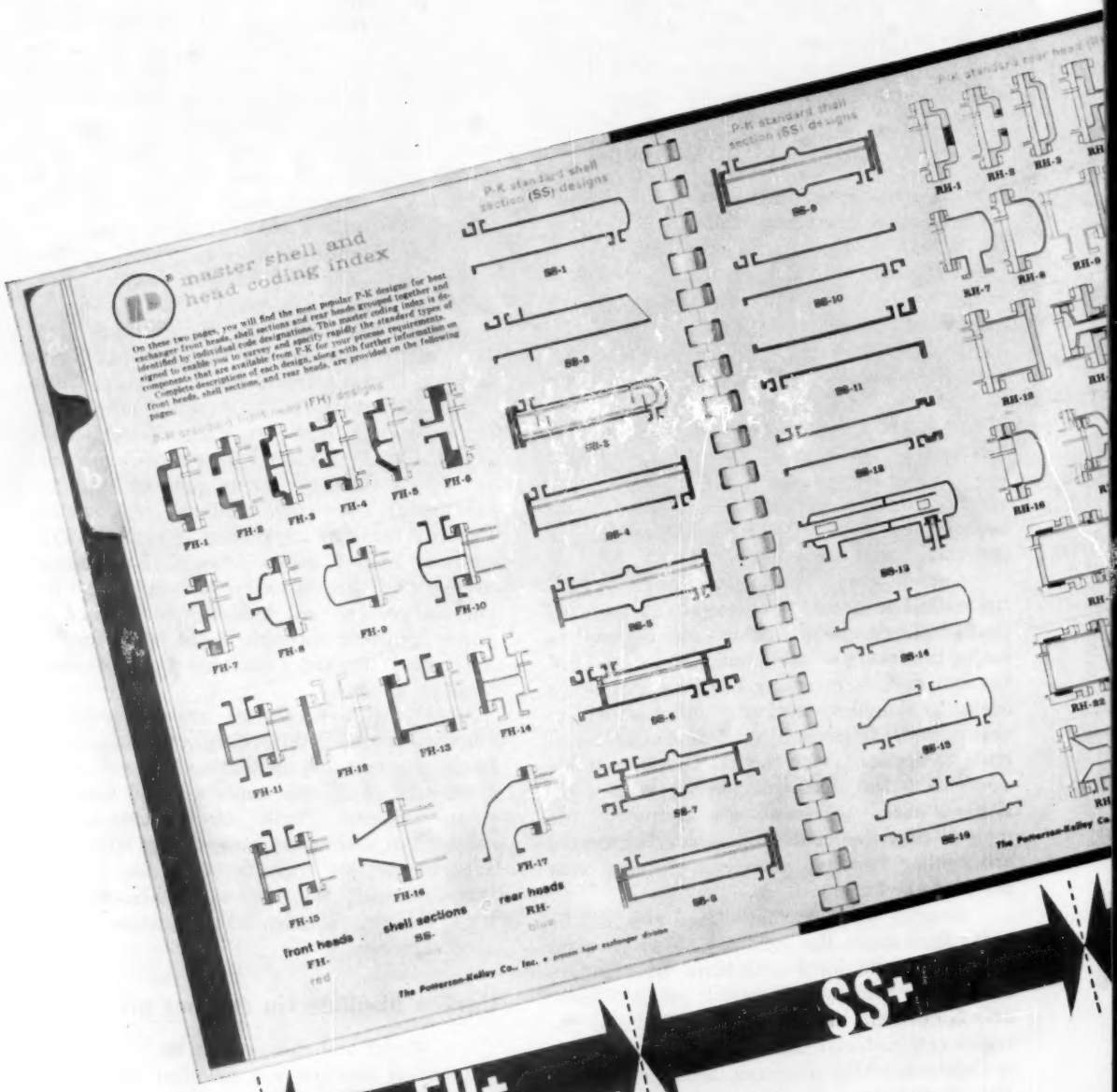
At least five columns are in service in Europe, distilling tall oil, caprolactam, other heavy organics and unidentified heat-sensitive chemicals. And four more will be installed soon. Columns, built by Mueller-Schuss (Weidenau, Germany), range from 20-in. dia. with 15 rotating trays to 55-in. dia. with 10 trays, all 16-ft. tall. Cost of a 39-in.-dia., 10-tray column, Mueller-Schuss estimates, is about $15,000.

Carbon bisulfide via cheaper process

A new and cheaper process for producing carbon bisulfide was unveiled last month by C. M. Thacker of Taylor Fibre Co. (Norristown, Pa.). Designed to feed on practically any hydrocarbon, flowsheet reportedly requires 25% less plant investment and 15% lower operating costs than the methane-fed processes that currently dominate the CS_2 marketplace (*Chem. Eng.*, Dec. 28, 1959, p. 26).

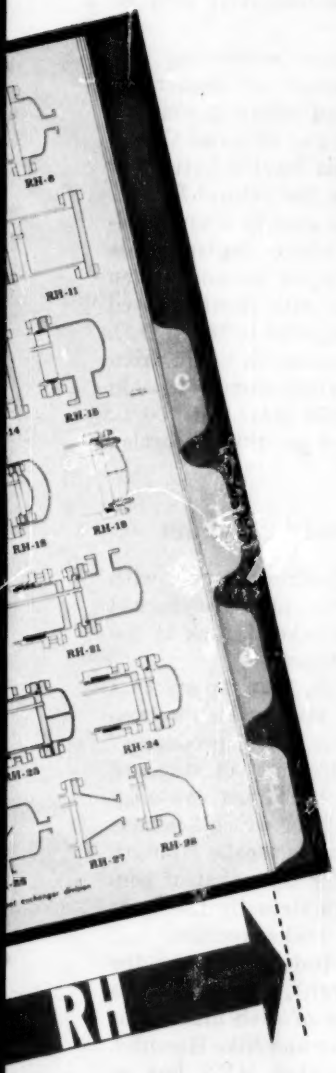
Key to Thacker's route is use of feeds with low hydrogen-to-carbon ratios such as gas oil or fuel oil. As a result, fewer moles of

(Continued on page 66)


master shell and head coding index
On these two pages, you will find the most popular P-K designs for heat exchanger front heads, shell sections and rear heads grouped together and identified by individual code designations. This master coding index is designed to enable you to survey and specify rapidly the standard types of components that are available from P-K for your process requirements.
Complete descriptions of each design, along with further information on front heads, shell sections, and rear heads, are provided on the following pages.
P-K standard shell section (SS) designs
P-K standard front head (FH) designs
P-K standard shell section (SS) designs
P-K standard rear head (RH) designs
front heads FH- red
shell sections SS-
rear heads RH- blue
The Patterson-Kelley Co., Inc. • process heat exchanger division
The Patterson-Kelley Co.

NEW SIMPLE FORMULA IN P-K HEAT EXCHANGER

FH+ SS+



AEC using P-K Heat Exchanger. This P-K Heat Exchanger runs 24 hours a day, 5 to 7 days a week, at the Uranium Processing Plant at Weldon Spring, Mo., operated for the AEC by Mallinckrodt Chemical Works. Although placed in operation in April 1958, and handling highly corrosive hydrofluoric acid at temperatures above 300°F., this two-pass shell and tube type unit has never once required maintenance.

Select the *Front Head* you want, from the *FH* group. Add the *Shell Section* you want, from the *SS* group. Add the *Rear Head* you want, from the *RH* group.

Follow these three simple steps and the formula above enables you to select the "designed" heat exchanger that meets your requirements.

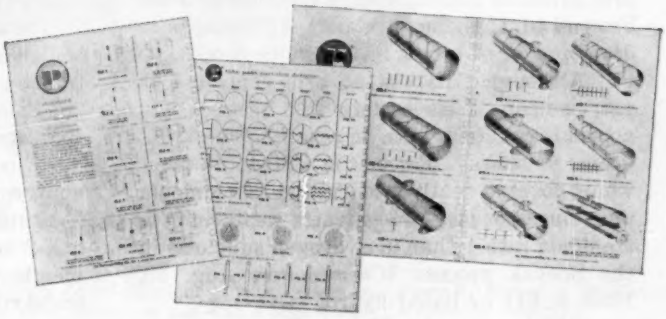
As you can see, the two pages at left from the new P-K Heat Exchanger Manual provide a master coding index. This makes it possible to rapidly survey and specify the standard interchangeable components available from P-K. Succeeding pages treat design features of each component in detail and save you time when you want to determine their suitability for your application.

Suppose, for example you want an exchanger with the following: front head bonnet, multi-pass, radial flanged connections; shell section with straight tube floating head, and pull through removable bundle construction; straight tube floating rear head, pull through removable bundle and shell cover plate, with multiple pass. Consult your P-K Manual, pages b-1 through b-18. Then specify FH-10+SS-10+RH-14.

Clear, parallel picturization of standard gasket joints, tube pass partitions, shell baffles and other components simplifies the underlying details of designs.

Other sections of the manual standardize terminology, review fundamentals of heat transfer and design, even discuss economic considerations.

Since available copies of the new P-K Heat Exchanger Manual are limited in number, they are reserved primarily for those in the process industries who can most profitably use the information. If you design or specify heat exchangers, write us on your company letterhead, outlining briefly the areas of your interest. A few copies are available to students and non-technical personnel at a nominal charge. The Patterson-Kelley Co., Inc., 112 Burson Street, East Stroudsburg, Pa.



MANUAL HELPS YOU SELECT YOUR HEAT EXCHANGER

Patterson Kelley
Heat Exchanger Division

H_2S per mole of CS_2 are formed than with methane feed, thus permitting considerable reduction in size of purification equipment required. Moreover, Thacker's process eliminates need to purify feed itself which is a vital and costly step in methane-fed installations.

Believes Thacker, process' economics are attractive enough to tempt present CS_2 consumers to build and operate their own small on-site production units. And process would allow present CS_2 producers to expand their facilities quite simply. All that would be needed is additional reactor system since existing purification columns at higher outputs wouldn't be required to handle any more H_2S.

Thacker (who developed the original methane process while with Pure Oil) declares that, with a gas-oil feedstock, process gets almost 100% conversion per pass over an unidentified catalyst. Each ton CS_2 produced requires 2,501 lb. vaporized sulfur with 816 lb. sulfur recycling. By comparision, in methane process with 75% conversion, 4,940 lb. sulfur must be vaporized and 3,256 lb. recycled.

So far Thacker's findings have only been demonstrated on a lab scale. But process is now being made available for pilot plant development by interested companies.

New approach to heavy water piloted

Confident that the heavy-water-moderated reactor will win wide acceptance, especially in those countries that have access only to natural uranium nuclear fuel, Constructors John Brown Ltd. (London, England) is pushing pilot development of a new heavy water process.

Although CJB has no firm contracts as yet, company feels certain that process will appeal to countries with large agricultural programs underway. Reason: A CJB-route plant would dovetail neatly into a standard ammonia unit since process concentrates deuterium in ammonia rather than in hydrogen sulfide as in the Spevak process (*Chementator*, Aug. 10, 1959, p. 51) or liquid hydrogen.

CJB has completed preliminary engineering design on a 28-metric-ton/yr. facility. Company estimates capital investment of plant at about $6 million. Operating cost, assuming 15% to cover interest and depreciation, figures out to roughly $21.50/lb.

In process, ammonia synthesis gas is cooled to —40 C., then passed to a packed tower at 250 atm. where it contacts a liquid NH_3 stream containing potassium amide catalyst. About 70% of deuterium is stripped from synthesis gas.

Liquid ammonia, now containing five times the natural amount of deuterium, passes to a second column where it contacts deuterium-enriched NH_3 gas at —40 C. and 250 atm. Liquid ammonia leaving bottom of column contains 23 times the natural D_2 content. Half of this stream goes to a seven-column distillation train where deuterium is concentrated to 75%. Liquid ammonia then exchanges its deuterium with demineralized water and water is concentrated to 99.8% D_2O.

Remainder of rich ammonia liquid from exchange section contacts lean ammonia gas in a column operating at 250 atm. and 100 C. This provides the enriched gas that's recycled to the second column.

Rocket steel eyes industrial market

An exceptionally high-strength steel, with a foothold secured in the pressure-plagued rocket business, will now take a crack at the general industrial marketplace.

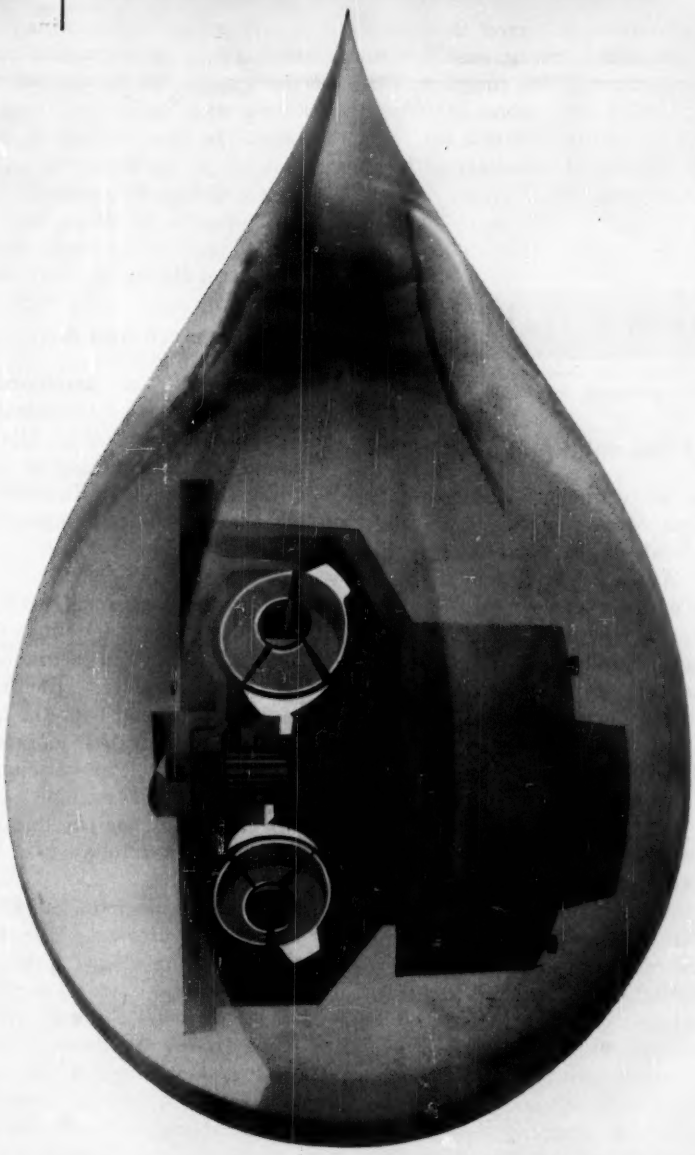
Scaife Co. (Pittsburgh, Pa.) reports that it's setting up a program under which a "reasonable number of qualified steel producers" will be licensed to manufacture all standard mill forms of its cobalt-modified low-alloy MX-2 steel. This material, for which Scaife is now seeking patents, boasts a tensile strength two to three times greater than that of conventional steels yet offers virtually the same ease of fabrication as its weaker cousins.

Scaife's alloy, developed jointly with the Mellon Institute (Pittsburgh), currently serves in the rocket motor cases of such missiles as the Falcon, Hawk, Matador and Nike Hercules. But Scaife feels certain that MX-2 has an "enormous potential" in the chemical, petroleum, construction and automotive industries. Ventures a company spokesman, market for MX-2 in pressure vessels, piping, structural members, various machined forgings and gears could run "in excess of $100 million/yr."

U. S. Steel, Universal Cyclops, Latrobe Steel and Allegheny Ludlum are among the steel firms that have expressed more than passing interest in Scaife's super-strength alloy. In fact, USS and Universal recently announced that they are making forging billets, bar wire, plate sheet and strip of a steel based closely on Scaife's development.

MX-2 derives its advantages chiefly from its composition rather than from some special

DOW | **BROMINE DEVELOPMENTS**



BUILD DENSE FLUIDS WITH BROMINE

Bromine, the only element besides mercury that's a liquid under ordinary conditions, has a density more than three times that of water. Specific gravity is 3.1 at 20/15°C. This property, plus ready ability to unite with other chemical compounds, makes bromine ideal for building high density fluids.

Take hydraulics, for example. Engineers are turning to nonflammable, brominated compounds to develop high density fluids to achieve more compact hydraulic systems.

Close tolerances of moving parts in delicate mechanisms become less important when high density brominated fluids are used. Hydraulic equipment size decreases with an increase in fluid density. You may also increase the power output of your present equipment by replacing the fluid now in use with a high density brominated system.

In other applications, bromine and brominated compounds serve as chemical intermediates in thousands of reactions. Recent fruits of continued research are new brominated compounds especially suited for specialized fire-fighting tasks.

Dow's first product nearly 70 years ago was bromine. Today, besides high-purity elemental bromine, Dow produces over 100 brominated compounds, with new ones constantly under study. And Dow is anxious to explore bromine's potential for helping you improve products and processes. For more information, write THE DOW CHEMICAL COMPANY, Midland, Mich., Chemicals Merchandising Dept. 651AK7-11.

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heat treating techniques. A typical alloy contains 0.40% carbon, 0.70% manganese, 1.00% silicon, 1.10% chromium, 0.25% molybdenum, 0.15% vanadium and 1.00% cobalt. It offers tensile strengths as high as 290,000 psi., can be easily and reliably formed, machined, welded and heat treated.

Tomorrow's Technology

Today's embryonic developments which have special significance for chemical engineers

Needed: Fluid-solid pumping data

In one area of technology—the pumping of fluid-solid mixtures—most engineers are wandering in a wild jungle of confusion if not total ignorance. And a good many of them are not even aware of their sorry plight.

That's the conclusion the Hydraulic Institute (New York) has been forced to draw after nearly five years of trying to put together engineering information on fluid-solid pumping for its revised edition of the highly regarded Standards of the Hydraulic Institute. Despite intense efforts, the Institute reports, at this time it can not print a single unqualified number on the subject.

Initially the Institute thought it could do the job by a thorough survey of the existing literature. But it quickly discovered that not only was the literature hopelessly meager on the subject but that the little that was available was frustratingly contradictory. HI's next move was to seek information, via two detailed questionnaires, from some 80 firms and individuals considered to have knowledge and experience in fluid-solid pumping (e.g., equipment manufacturers, education institutes, consulting engineers). Though it received an outstanding 77% return on its queries, HI reports that the results served only to further compound all the contradictions extant.

For example, here's one question that was posed to the experts on HI's questionnaires. "If you pump a fluid-solid mixture of silica sand, is the minimum velocity needed to keep it moving greater when the pipe is on a 45-degree slope rather than horizontal?" Yes, replied 53%; no, replied 47%. To say the least, HI considered itself hard pressed to prepare data on the basis of this sort of reply.

Chief obstacle in any attempt to make a disciplined technology out of what's now essentially a magical art was summed up neatly for *CE* by one industry observer. "Those who know won't talk and those who talk don't know." In light of this situation, HI suggests that a comprehensive research program, jointly financed by manufacturers and users of fluid-solid pumping equipment, should be carried out at several independent research institutes. HI would coordinate results.

Research and development briefs

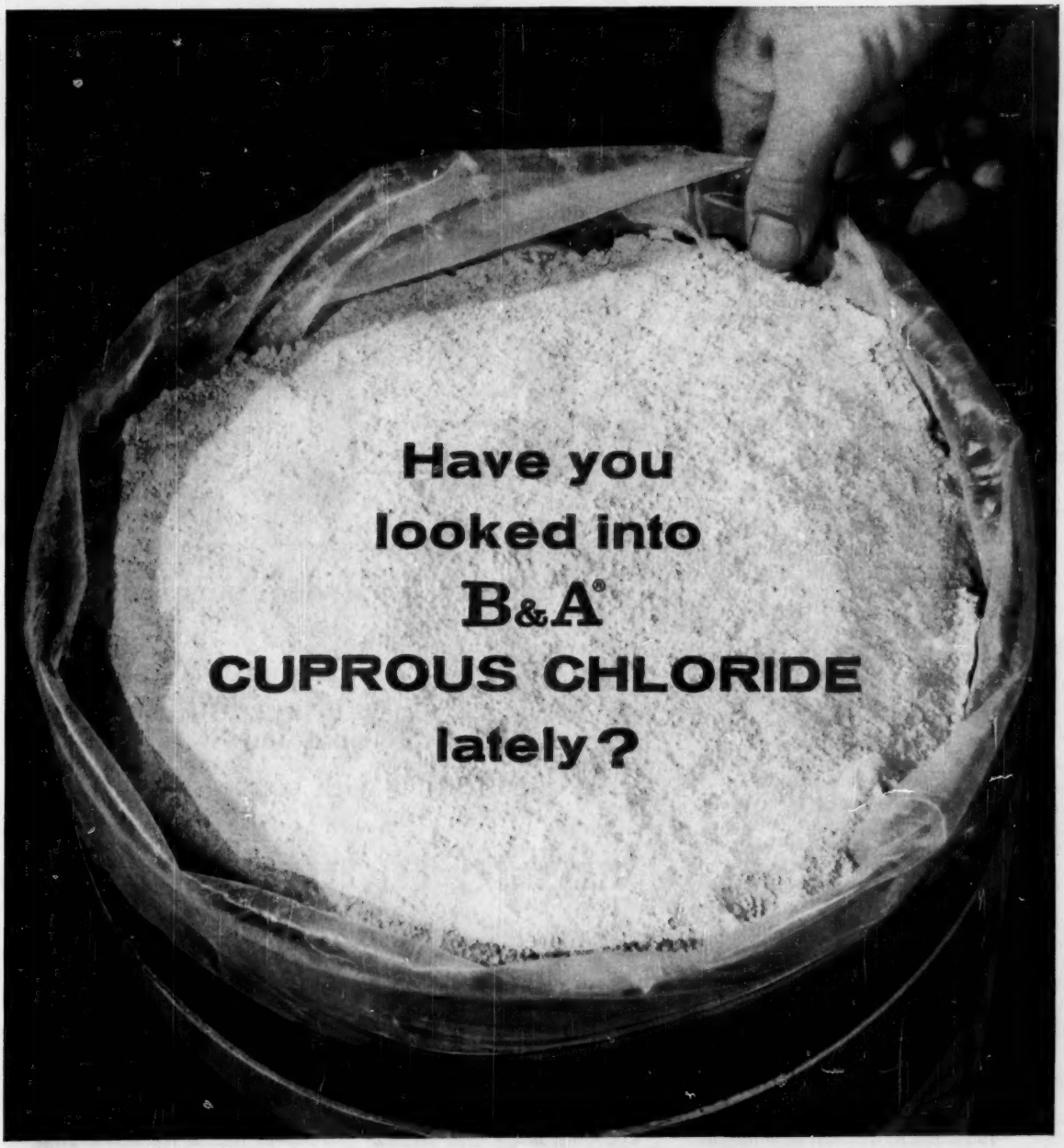
Guanidinium perchlorate for rockets? American Potash & Chemical Corp. thinks that there's a real possibility. Unusual organic compound, which company is producing in pilot quantities at West Hanover, Mass., offers all the characteristics of a good solid monopropellant, AP&CC believes.

Large, single refractory metal crystals have been grown by Linde Co. (Indianapolis) by much the same technique it uses to make synthetic sapphires. Electric-arc-fusion process has produced 1-in.-dia. by 1-ft.-long single crystals of tungsten, molybdenum, vanadium, tantalum as well as various metal compounds such as titanium carbide and molybdenum disilicide. Materials are ductile, very pure and strikingly easy to work at low temperatures.

Cloth spun from aluminum oxide fiber is reported by Horizons, Inc. (Cleveland). Company has developed process for producing various metal oxide fibers that withstand upwards of 4,000 F. and 1 million psi. Fabrics made from such fibers could be used as space vehicle skins, fire-fighting suits. An unidentified chemical firm is currently negotiating to license Horizons' development.

Coronene can be recovered from U.S. coal, Bureau of Mines reports. Researchers have found that Pennsylvania anthracite yields the rare chemical at rate of 1 lb/1,000 lb. coal when hydrogenated to pipeline gas. Material has application as dye base, was produced for that purpose in Germany during World War II as byproduct of synthetic fuels plants. It has never been used in this country chiefly because U.S. coal wasn't known to contain it. BuMines ventures that coronene recovery might help underwrite cost of coal gassification projects.

For more on DEVELOPMENTS.....70



If you're using copper salts as catalysts, it may pay you to look into General Chemical's B&A cuprous chloride—a product of outstanding quality. As America's leading supplier of reagents and fine chemicals, General Chemical has the productive capacity to serve the growing needs of tonnage users. And, its long experience in manufacturing cuprous chloride assures a product of the highest purity and uniformity.

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Can Irradiation Compete For Sterilization Use?

In spite of apparent apathy in this country towards use of radiation for process applications, enthusiasm in Britain continues high. Now come reliable—though officially unconfirmed—reports that three commercial irradiation plants, each with a capacity of 7 megarad-tons/day, will be built within 18 months for sterilizing medical and pharmaceutical products.

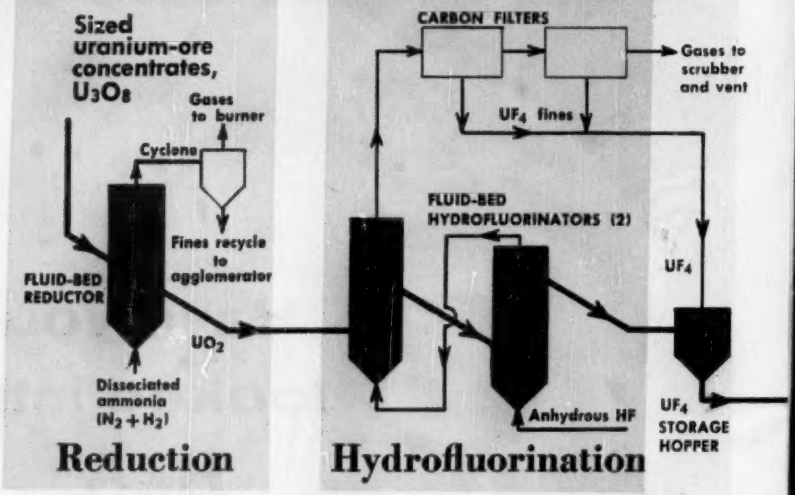
New facilities will be entirely privately owned, patterned after the Atomic Energy Authority's $250,000 prototype facility now in operation at Wantage, Eng. The AEA will retain responsibility only for monitoring health conditions in the commercial plants.

Attractiveness of radiation for use in sterilization, says an AEA spokesman, stems mainly from the relatively low cost of about $1.50/cu. ft. in an "optimized plant." Too, irradiation allows sterilization of plastic items which can't be heat-treated. Only other way of sterilizing plastic is contacting with ethylene oxide, but the AEA maintains that irradiation is cheaper in large, continuous facilities.

Planned commercial plants are expected to cost about $150-180,000 each exclusive of the cobalt-60 radiation source. Plants will operate on a 24-hr. basis, six days a week. The 150,000-curie radiation source will be sufficient to handle about 2½ tons of medical supplies per day.

Although no new cost figures are available, it is believed the AEA will be offering cobalt-60 from its Calder Hall and Chapelcross reactors at about 70¢/curie plus a small handling charge. This reduction from previously announced price of $1.40/curie is undoubtedly designed to stimulate private use of radiation.

Products listed for irradiation include plastic one-shot hypodermic syringes, sutures, plastic catheters, and dressings.



4 Steps Combine purification with conversion, as . . .

Private Industry Shows

In first privately owned nuclear feed materials plant, General Chemical's fluid-bed and distilling techniques shorten route from crude ore concentrates to UF_6.

Rounding out a year of successful operation, General Chemical's big nuclear gamble now belongs in industry's big winner class.

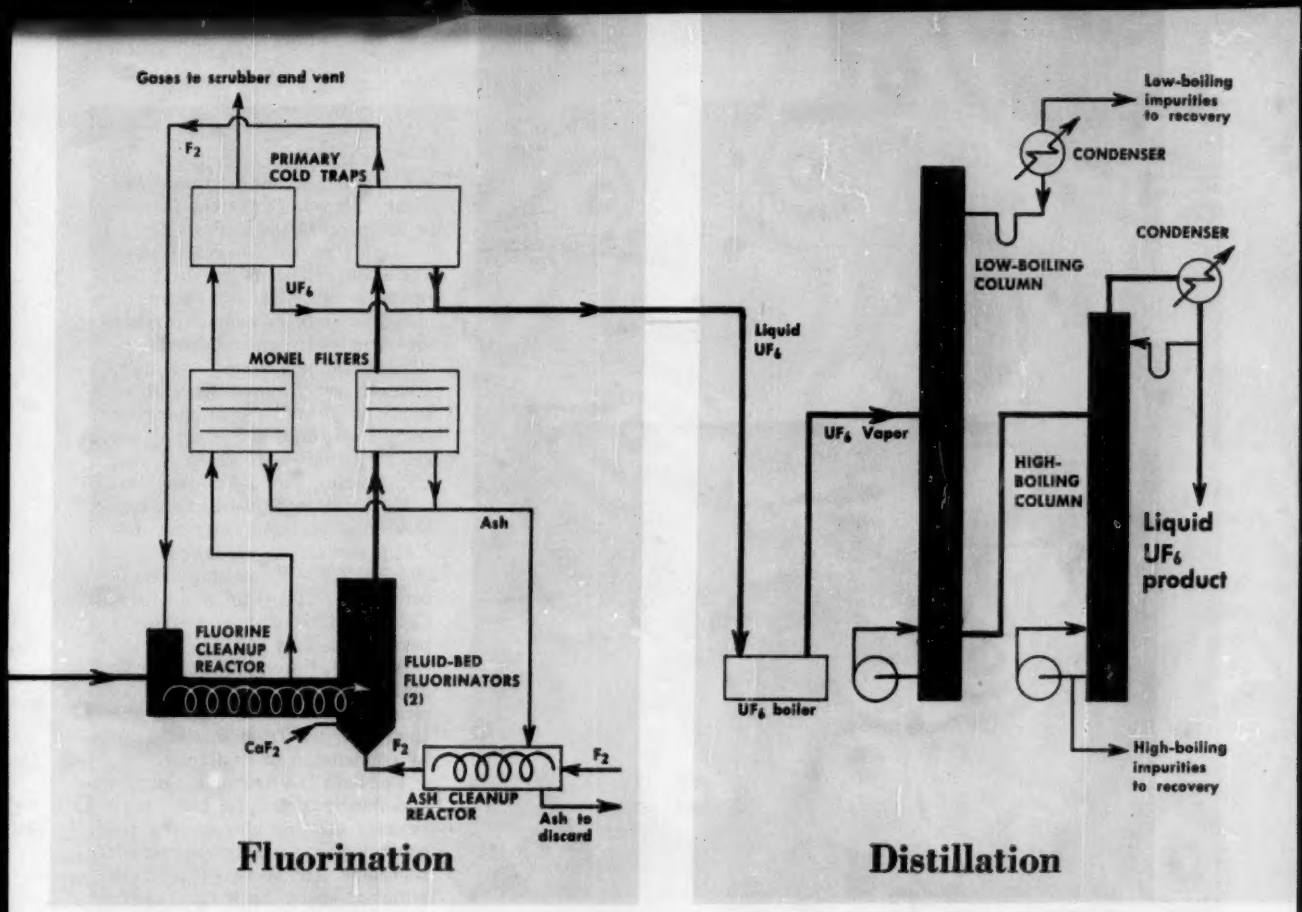
The gamble: Undertaking to convert 5,000 tons/yr. of crude uranium ore concentrates to pure UF_6 by fluid-bed and distilling techniques not used previously for large-scale preparation of nuclear feed materials in the United States.

The payoff: Elimination of need to purify concentrates by solvent extraction before conversion to UF_6. All impurities are removed during the actual process steps leading to UF_6.*

A graphic yardstick which shows how General Chemical marshalled its resources to win its gamble is the fact that less than three years elapsed from initiation of process development to startup of the 5,000 ton/yr. plant at Metropolis, Ill. And in June, the plant shipped its 10 millionth pound of product.

General shares credit with Ar-

* Earlier AEC processes require solvent extraction of ore concentrates to produce orange-salt feed (UO_3) for fluid-bed reduction to UO_2 (*Chem. Eng.*, Mar. 23, 1959, pp. 140-143).



How to Simplify UF_6 Output

gonne National Laboratory for piloting the fluid-bed stages of the process. But General worked alone in applying distillation to final purification of UF_6 product.

▶**Knocking Out Impurities**—To make its gamble pay off, General integrated the following steps into an operating process:

- Direct fluid-bed reduction of U_3O_8 to UO_2.
- Fluid-bed hydrofluorination of impure UO_2 to a purer UF_4.
- Fluid-bed fluorination of UF_4 to still purer UF_6.
- Distillation of liquid UF_6 to final pure product UF_6.

Fluid-bed hydrogen reduction of concentrate to dioxide removes sulfur as offgas hydrogen sulfide. Fluid-bed hydrofluorination of dioxide drives off bismuth, silicon, molybdenum and vanadium as volatile fluorides.

Then, large quantities of sodium, calcium, iron and magnesium drop out in the fluorination ash. Finally, residual trace impurities are removed by UF_6 distillation.

▶**Processing Complications** — Except for the last step, processing involves high-temperature, exothermic reactions of impure solids with gases. To maximize conversion and prevent sintering and plugging of the fluid bed, temperatures must be controlled closely.

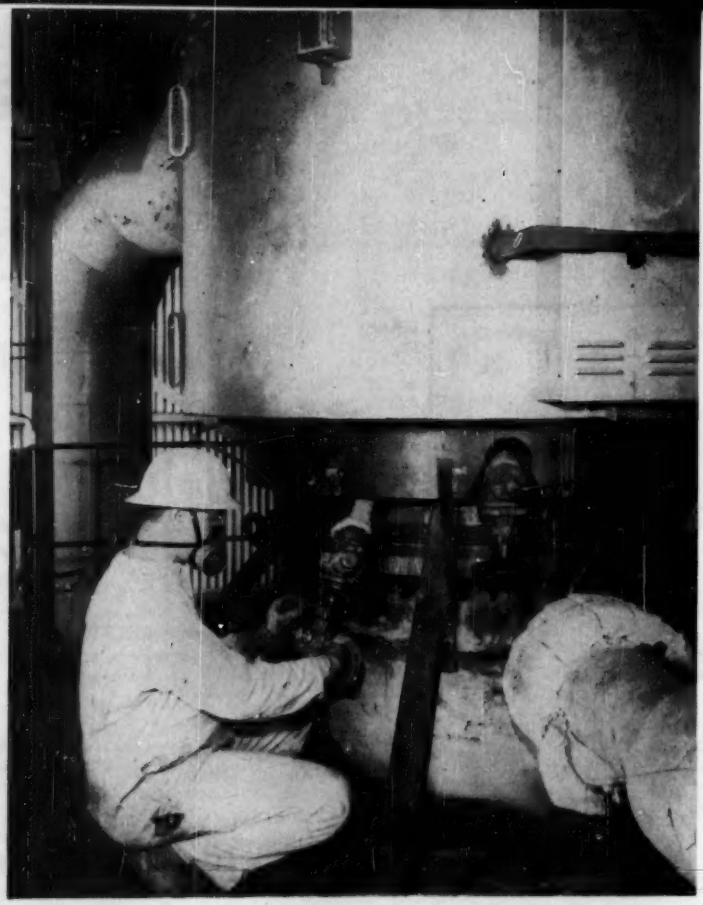
Hydrofluorination poses, perhaps, the trickiest temperature control situation. Here, General Chemical employs two fluid-bed reactors in series to permit approximation of a temperature profile.

First reactor operates at 750 F., with a bed of UF_4 to permit close control of heat balance; reaction proceeds to more than 95% completion. Second reactor operating at 800-1,000 F. drives the reversible reaction more nearly to completion than is possible with single reactor.

▶**Set Feed Specs**—Because feed characteristics can alter the effectiveness of controlling reactions through temperature regulation, General is highly selective in choice of feed ore concentrates.

For example, high sodium-carbonate leach concentrates require higher temperatures because they are relatively unreactive. As a further complication, sodium plugs the bed, even at low temperatures, in all three process steps. Therefore, General Chemical avoids carbonate-leach ore concentrates, specifies use of acid-leach concentrates.

Other factors in selection of



TECHNICIAN checks on UF_6 process at General Chemical's Metropolis plant by taking UF_4 (green salt) sample from primary hydrofluorinator.

feed are impurity content and particle size. High impurity content leads to greater reagent consumption in processing. So, General prefers to use only concentrates from ore mills that can hold down impurities.

Even relatively pure concentrates often are too fine or too coarse for satisfactory fluid-bed operation. But agglomerating and sizing overcome this difficulty.

▶ **Agglomerate First** — At Metropolis, the UF_6 process starts with an agglomeration step at the top of a six-story gravity flow plant. In a high-velocity pug mill, ore concentrates are agglomerated with a small quantity of water.

After hardening in an indirect-fired rotary kiln at 700-900 F., the agglomerates go through roll crushing and screening to −40, +200-mesh particle-size range. Fines recycle to pug mill and oversize to crusher.

Passing through screw feeder into top of fluid-bed reduction reactor, feed contacts hydrogen flowing upward at a superficial velocity of 0.2-0.7 ft./sec. Within the reaction zone, heated to 1,000-1,200 F. by external electric furnace, the hydrogen reduces U_3O_8 to UO_2. Off gases, stripped free of solids by cyclone, are burned.

▶ **On to Hydrofluorinators** — Discharging from reduction stage, UO_2 goes to top of the first of two Inconel hydrofluorinators.

Anhydrous HF reaction gas and fluidizing medium flows through the hydrofluorinators countercurrent to flow of solids. Gas discharging from the second stage is filtered through carbon. Thus freed of fines, it can feed into first stage without plugging the gas disperser.

Off gases from primary stage are filtered and scrubbed before venting to atmosphere.

▶ **Final Conversion**—The intermediate green salt, UF_4, moves from hydrofluorinators to complex fluorination system via screw feeder. Fluorination setup is fashioned for maximum fluorine utilization and uranium recovery, since both are key factors in the process economics.

In this setup, General Chemical uses two primary fluid-bed reactors operating in parallel, plus two auxiliary cleanup reactors, one upstream and one downstream from main reactors. Cleanup reactors capture unreacted UF_4 and F_2 discharging from main fluid-bed reactors by reacting them with fresh F_2 and UF_4 feeding into main reactors.

In the main fluid-bed fluorinators, fluorine gas converts the UF_4 green salt to gaseous UF_6 at 800-1,000 F. Because reactants convert entirely to gas, inert CaF_2 solid is used to provide a permanent fluid bed.

All UF_6 product gas from main reactors and the auxiliary cleanup reactors is filtered and then stripped from gas streams by condensing in cold traps.

For both the hydrofluorination and fluorination fluid beds, high velocity air provides cooling for control of the highly exothermic reactions. Air passes through the annular space between reactor and electric furnace. Nitrogen gas is available for fluidizing the beds to prevent fusion if feed should dwindle or stop.

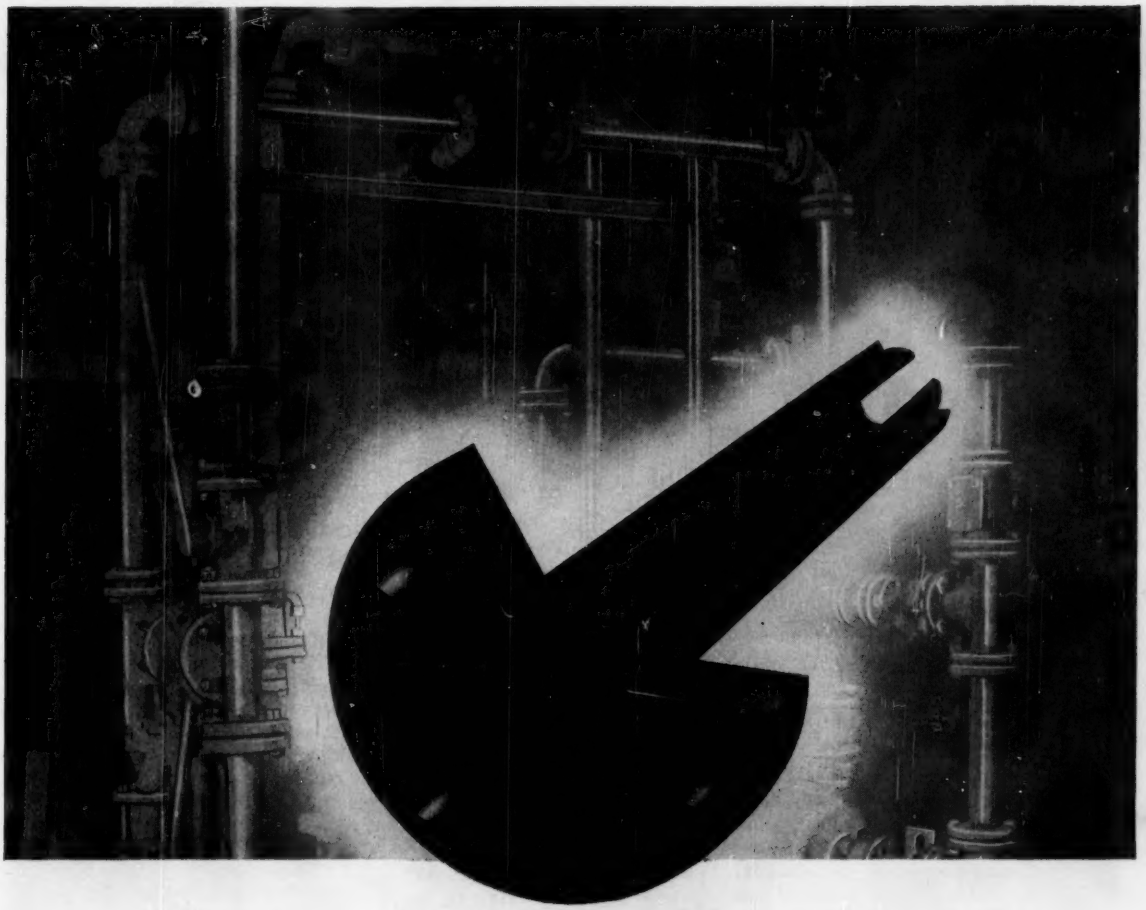
▶ **Final Cleanup**—Remaining in UF_6 product are vanadium as VOF_3 and traces of molybdenum, silicon, carbon, sulfur, iron and aluminum.

To remove these impurities, General feeds the UF_6 to a 120-ft., 100-tray distillation column operating at 85 psia. and 200 F. Vanadium oxyfluoride, molybdenum hexafluoride, hydrogen fluoride and other high volatile fluorides boil off overhead.

Bottoms from first column go to 55-ft., 45-tray column operating at 95 psia. and 240 F. Molybdenum oxyfluoride and nonvolatile fluorides of iron, aluminum, uranium, etc., discharge from this column as bottoms.

Pure UF_6 vapors overhead are condensed and packaged in 10-ton cylinders, each holding $200,000 worth of UF_6 for delivery to gaseous diffusion plants.

While General Chemical designed its process to compete with AEC routes to pure UF_6, the process could produce metal-grade UF_4 by addition of a step to reduce UF_6 to UF_4.



Plant saves $60,000 per month by switch to pipe lined with TEFLON®

In a plant manufacturing a chemical intermediate, excessive maintenance costs and product losses ran as high as $60,000 per month. Such frequent failures occurred in the process involving corrosives at high temperatures and pressures, that onstream time averaged only 75% during the first six months of operation. After a period of testing, more than 1500 feet of pipe lined with Du Pont TEFLON TFE-fluorocarbon resin were installed. Result: No failures of lined pipe occurred in over 2 years of service.

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The liner flared over the flanges provides protection for the steel from the process fluid and eliminates the need for additional gasketing. Installation costs are further reduced because the pipe is equipped with standard flanged fittings which are easily connected. And the need for careful aligning, hanging, welding and other special procedures is eliminated.

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First Offshore Sulfur Mine Now in Production

The world's first offshore sulfur mine, owned and operated by Freeport Sulphur Co. (New York), has gone into commercial operation. Located in some 50 ft. of water seven miles off the coast of Grand Isle, La., in the Mexican Gulf's Hurricane Alley, the $30-million installation is classed as the third largest Frasch plant in existence. It has an average hot-water capacity of 5 million gal./day. Its underwater pipeline is designed to transport 4,500 tons/day of molten sulfur to the mainland barge terminal.

Plant taps one of the largest sulfur deposits known, some 2,000 ft. beneath the floor of the Gulf, which was discovered by Humble Oil & Refining Co. during offshore-oil explorations. Humble assigned sulfur rights to Freeport but will receive approximately 50% of the net profits (after taxes) from the sulfur company's operations. The huge man-made island on which the Frasch plant stands stretches roughly ½ mile across the Gulf, will eventually be extended to form a giant "Y" almost one mile long. Its lower floor stands 60 ft. above the water; top deck elevation is 75 ft.

New Phthalic Catalyst Broadens Process Base

Scientific Design Co., New York, has come up with an answer to naphthalene shortage problems faced by phthalic anhydride producers during downturns in steel production. SD has developed a versatile catalyst that produces phthalic anhydride from either naphthalene or ortho-xylene with equal ease and high yields. Ortho-xylene, being a petroleum product, frees phthalic producers from the vagaries of the steel business. (For another answer to naphthalene shortage problems, see *Chem. Eng.*, June 13, 1960, p. 82, also Chementator in this issue.)

New catalyst will be incorporated in a new xylene-based phthalic plant which SD is building in Europe. Although not stated, yields achieved with the new catalyst are believed to be 85-90% of theoretical.

Use of o-xylene feedstocks for phthalic production isn't new: Oronite has been using it for around 15 years. And other producers have used their naphthalene-designed catalysts to oxidize o-xylene during severe naphthalene shortages, taking a sacrifice in yields. With new catalyst, however, phthalic makers can tailor production to raw material supply situations, and can even use mixtures of naphthalene and xylene if market conditions so dictate.

Non-Nuclear Phase of Project Plowshare Starts

Though still awaiting outcome of the international talks on nuclear-weapons test ban now under way in Geneva, the Atomic Energy Commission has started moving ahead with the non-nuclear phase of its Project Plowshare studies of the potential industrial applications of nuclear explosions.

This month the University of California's Lawrence Radiation Lab (Livermore, Calif.), supervising AEC's program, set off a 500-ton chemical detonation some 125 ft. below ground at AEC's Yucca Flats, Nev., test site. It was the first of a scheduled series of similar blasts aimed at gathering information on the relationship between energy yields, burial depths and crater size of large underground explosions. AEC believes that data from non-nuclear blasts will be applicable in developing techniques for harnessing A- and H-bombs to vast construction jobs, isotope and power production, development of natural resources.

Last month the Lawrence Lab people supervised the detonation of two other high-explosive chemical charges beneath the Bureau of Mines, experimental oil shale mine near Rifle, Colo. One, a 1,000-lb. charge, was buried 115 ft.; the other, a 5,000-lb. charge, was buried 125 ft. Object of these blasts was to help determine the feasibility of using a nuclear explosion to fracture oil shale at a reduced cost.

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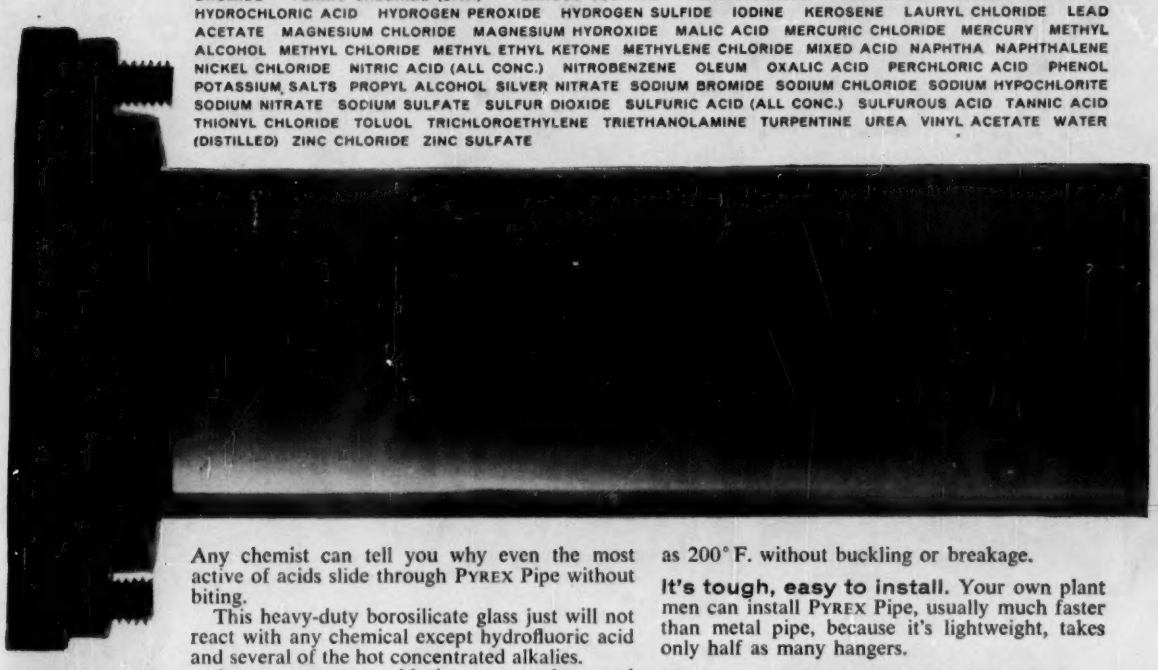

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New Future for Toluene in Fibers?

Take a look at the attractions claimed for new route to terephthalic acid and see why toluene may win favor as starting material for this polyester intermediate.

Striving to use a less costly starting material than *p*-xylene, Bergbau-Forschung G.m.b.H. (Essen-Kray, Germany) has evolved a terephthalic acid process based on toluene.

As disclosed for the first time, April 25-30, at the biennial meeting of the German Chemical Society in Stuttgart, the process produces a 57-43 mixture of terephthalic (*p*-phthalic) and *o*-phthalic acids which is easy to separate.

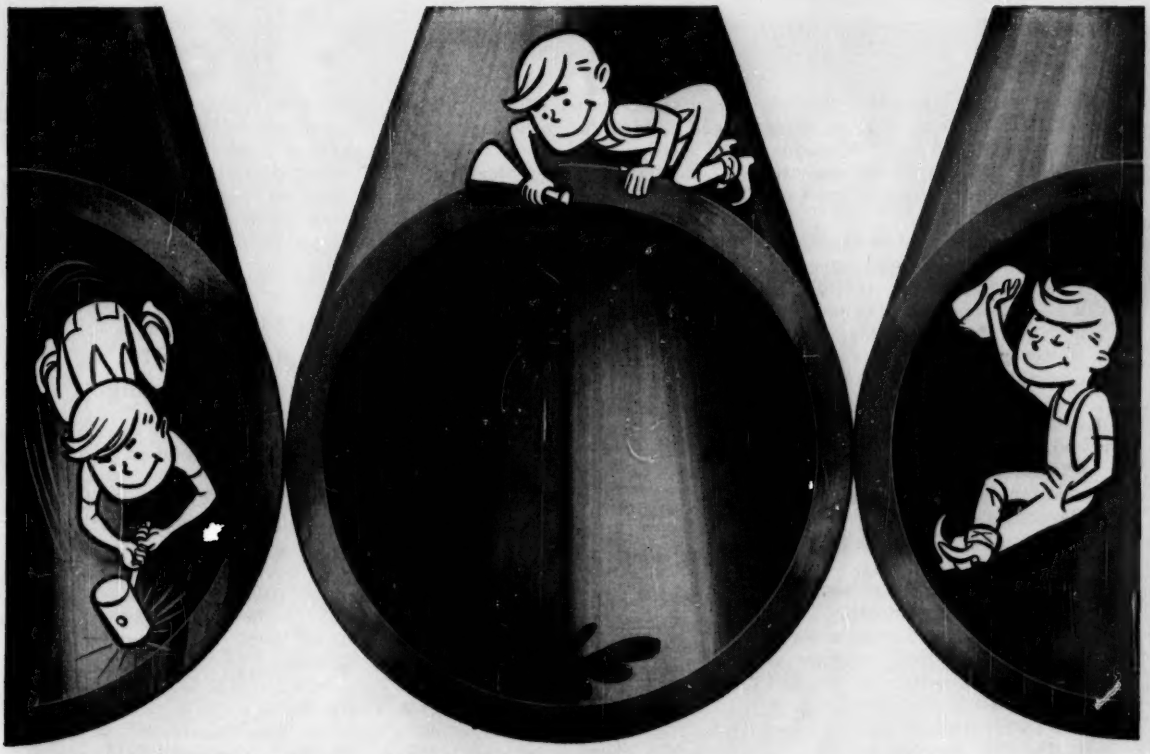
Despite the high yield of *o*-phthalic acid, Bergbau maintains that process offers favorable cost. Undoubtedly, choice of toluene as feedstock contributes greatly to this position.

By choosing toluene, Bergbau continues the German trend toward terephthalic processes which steer clear of costly *p*-xylene starting material (see *Chem. Eng.*, Aug. 10, 1959, p. 53 for description of Henkel & Co.'s benzene-K_2CO_3 terephthalic acid process).

▶ **Stands on Its Own**—But Bergbau's process boasts some features of its own, too. Terephthalic-acid product is said to be purer than that from any other process—impurities amount to about 0.1% chlorine and 0.1% nitrogen.

A centrifuging and washing step easily extracts the product at the end of the process. And short reaction times and low inorganic acid concentrations keep byproduct and corrosion problems minimized.

▶ **Present Status**—At present, the process is operating at Bergbau's Essen-Kray plant in a 440-lb./day pilot unit which super-



The smoother surface of CONTOUR-WELDED* STAINLESS TUBING *gives it greater resistance to corrosion*

Recent tests prove: (1) *Contour-welded* tubing is smoother than any other tubing, and (2) this extra smoothness provides greater resistance to corrosion.

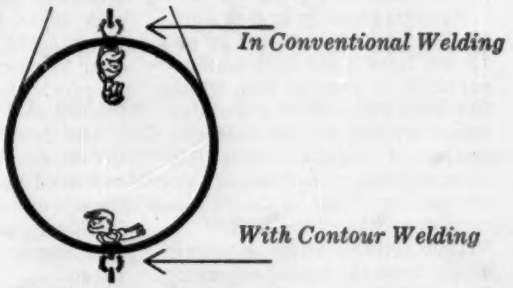
Here's how TRENTWELD® tubing, made by the exclusive *Contour-Weld* process, compares with other full-finished tubing:

- It's smoother than seamless because it's formed from uniformly rolled strip steel, whereas seamless is extruded or pierced.
- It's smoother than other welded tubing because the *Contour-Weld* process, patented by Trent, virtually eliminates the weld bead.

Other tests prove this smoother surface provides *increased resistance to corrosion* — because there are fewer focal points for corrosive attack. Not only that, the smoother surface ensures *longer fatigue life* and *less product incrustation.*

But get full details. Our free 48-page *"Trentweld* Manual" gives complete data on *Contour-Welded* tubing in sizes from ⅛" to 40" O.D., in stainless and high alloy steels, titanium, zirconium, zircalloy and Hastelloy.† Write: Trent Tube Company, Box 2518, Pittsburgh, Pa.

†Trademark Haynes Stellite Co.



In **CONVENTIONAL WELDING** of tubes, gravity pulls the molten metal down to form a bead that is difficult to remove by cold working. And cold working may lead to undercuts, focal points for fatigue cracks and corrosive attacks. Cleaning becomes difficult.

*With **CONTOUR-WELDING** the tube is welded at the bottom. Gravity still pulls the molten metal down inside the tube, but now the weld area corresponds to the contour of the tube. There's virtually no weld bulge on the inside surface. And even on the O.D., the weld seam more closely conforms to the contour of the tubing.

CONTOUR TRENTWELD

stainless and high alloy pipe and tubing

TRENT TUBE COMPANY

Subsidiary of Crucible Steel Company of America • GENERAL OFFICES: East Troy, Wisc. • MILLS: East Troy, Wisc.; Fullerton, Calif.

sedes earlier apparatus having one-tenth this output. Pilot plant can be switched easily to production of other polyvalent aromatic acids, highlighting the broad potential of process.

As evidence of product quality, Bergbau reveals that a polyester-fiber manufacturer recently tried a 220-lb. sample of the material and reported favorable results. However, the product is not pure enough for direct use with glycols in making synthetic fibers; hence it is sold as a dimethyl ester.

▶ **Chloromethylate Twice**—The chloromethylation process, as Bergbau's chemists unobtrusively call it, follows a taut and economical flowsheet*.

First part of the process is the actual chloromethylation, and here Bergbau achieves a 98%-pure chloromethyl toluene by using two reactors in tandem. A four-to-one mixture of toluene and paraformaldehyde is pumped to the first reactor, where it is combined with 33% HCl for reaction at 158 F. Reacted mixture goes to a separator.

Organic phase from the separator (about 60% chloromethyl toluene, plus unconverted toluene) feeds into the second reactor for additional treatment with HCl, followed again by phase separation.

Aqueous phase from each separator is sent to the top of an absorber. Here it descends countercurrently to gaseous HCl, which has been released in a washing tower located in the oxidation section of the unit. The HCl stream leaving bottom of absorber is recycled to the chloromethylation reactors.

▶ **Then Oxidize Twice**—Organic phase from the second separator—a 98%-pure mixture of 57 parts para, 43 parts ortho isomers—is ready to be oxidized. For the first oxidation step it is combined with 44% HNO_3 and reacted for 1 hr. at about 195-203 F. Result is a mixture of chlorine-free toluylic acids and 37% HNO_3.

This step also produces an overhead gas stream, which flows to an H_2SO_4 gas-washing tower. The tower releases HCl gas (for recycle to the chloromethylation operations), and recovers nitrogen oxides for reconcentration of HNO_3.

Meanwhile the chlorine-free stream passes to the second oxidation reactor, a tube-shaped vessel about 4 in. dia. by 13 ft. high. Here the reaction, at 20 atm. pressure and 320 F., is completed in one hour.

Terephthalic acid crystallizes readily from the oxidized mixture and is separated in a centrifuge. To recover *o*-phthalic acid a further evaporation step is necessary.

*Austrian patent 202,995; German patent DAS 1,065,845.

West Coast Sea-Water Desalinizer Finds Home

The 1-million-gal./day, multistage flash-distillation desalination plant, planned by the Interior Dept. as the West Coast facility in its five-plant demonstration saline-water conversion program, has finally found a home. But in order to accomplish this long-sought feat (*Chem. Eng.*, June 13, p. 82), it was forced to drop its nuclear heat source in favor of a conventional boiler.

Plant will be erected on Point Loma at San Diego, Calif., as originally planned. But instead of a 40,000-kw. (thermal) low-temperature process-heat nuclear reactor, the plant now will be provided with steam from a fossil-fueled facility.

The Safeguards Committee of the Atomic Energy Commission had ruled against Point Loma as the site of a nuclear reactor after the Navy, which plans to operate a nuclear submarine base at San Diego, had raised objections. Navy feared that any radioactivity problem in the area created by the desalinizer's reactor would be blamed on its subs. AEC objected to the site on the basis of the temperature inversions in the area that trap large volumes of air, thus would compound hazard of any nuclear "incident" such as radiation leakage from desalinizer's reactor.

Interior Dept.'s search for another site proved fruitless. Chief reason: From the viewpoint of suitability for a desalination facility, none of the proposed alternate sites could meet its criteria as well as Point Loma. And since study of desalination, not nuclear reactor performance, is the main object of the installation, Interior Dept. agreed to drop the reactor in order to get the site.

Tetramethyl Lead Use, Production Stepping Up

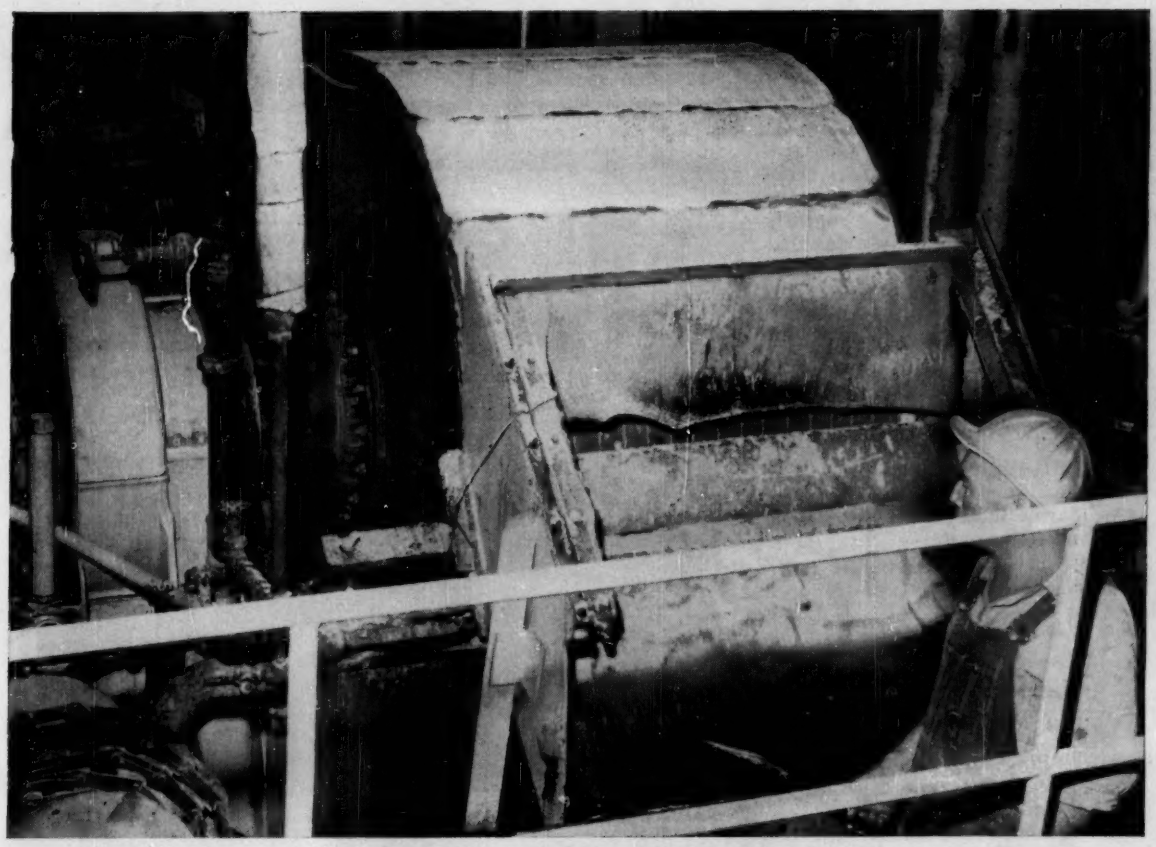
Tetramethyl lead is starting to gain a solid foothold as an antiknock, octane-boosting gasoline additive to be used by itself or in combination with tetraethyl lead, in auto fuels.

Last month California Oil Co. (Perth Amboy, N. J.) announced that its Chevron service stations in northern New Jersey and southern New York have begun blending TML in Chevron Supreme premium auto fuel. Now Caloil is making plans to extend "Methyl" marketing throughout 13 East Coast states.

Mobil Oil Co. (New York), which began marketing Mobil Methyl gasoline in the Syracuse, N. Y., area in May (*Chementator*, June 13, p. 69), now reports that it has introduced TML premium gasoline at its service stations in Sioux City, Iowa, and throughout Venezuela.

On the producers' side, too, TML activity is stepping up. The new firm, Houston Chemical Co., formed as a joint venture of Philadelphia & Reading and Chatham Chemical (*Chementator*, June 27, p. 53), has declared that it's getting into TML manufacture. Company plans to build a plant at Beaumont, Tex., right next door to Mobil's refinery, which will compete with Ethyl's TML facility at Baton Rouge, La., and Du Pont's a-building TML plant at Deepwater, N. J.

Behind this burst of activity stands the fact that, in Mobil engineers' words, "TML provides a superior means of increasing the octane number of gasoline made by catalytic reforming, the process used by most refiners today to make premium-grade gasolines." Substitution of TML for TEL in cat reformate gasolines on an equivalent lead basis increases octane rating by more than three numbers in manual-



Vacuum filter extracts mixed salts from a brine containing 12-15% $MgCl_2$, 7.5% $MgSO_4$, 4% NaCl, 5% KCl. Monel alloy resists all these corrosives and also overcomes the possibility of failure due to chloride ion stress-corrosion cracking. Filter is installed at Carlsbad, New Mexico plant of International Minerals and Chemical Corporation.

How Monel alloy stopped $MgCl_2$ stress-corrosion cracking of this filter

Chloride ion stress-corrosion cracking destroyed the original core of this drum filter in less than six months. During this time, general corrosion of the core contaminated the process stream with heavy metal salts.

Then, engineers of International Minerals and Chemical Corp. replaced the cracked core with one made of Monel* nickel-copper alloy. After the Monel alloy core was installed, you could scarcely believe it was the same machine. Trouble vanished overnight.

When stress-corrosion is a problem...

Monel alloy...or one of the other high nickel Huntington Alloy Products... can be depended upon to control it.

Monel alloy is free from chloride ion stress-corrosion cracking... under conditions of total immersion, intermittent wetting and drying or vapor exposure, and in the presence of residual welding or applied stresses and crevices.

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Easy to fabricate

Monel alloy is not an exotic metal. It's readily available. What's more, fabricators know exactly how to cast, shape, and weld it for use in pumps, piping, coils and all kinds of processing vessels.

For information on the engineering properties of Monel alloy and for advice on applying those properties to specific items of equipment, contact:

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HUNTINGTON ALLOY PRODUCTS DIVISION
The International Nickel Company, Inc.
Huntington 17 West Virginia

What every engineer should know about Chloride Ion Stress-Corrosion Cracking

Cracks . . . large, straight or branched, usually transgranular but may be intergranular.

Causes . . . It is best explained as an electro-chemical mechanism with crack initiation being related to the available oxygen, specific concentrations of the chloride ion, and the stress level.

Potential . . . Stress-corrosion cracking has been observed in engineering materials that have been cold worked, rolled, welded, periodically wetted and dried. It may occur at stresses as low as 2000 psi; water containing as low as 50 parts per million chloride and at temperatures as low as 100°C.

MONEL®

transmission cars. In automatic-transmission cars, TML boosts octane rating as much as two numbers. And what's more, these gains can be accomplished at no additional cost. Caloil supports this contention by declaring that its "Chevron Supreme with Methyl" will cost no more.

In light of these facts, more gasoline manufacturers and distributors are expected to be attracted to TML blending. And the predictions that within five years 50% of all gasoline marketed in the U.S. will contain TML, made at the time that Standard Oil of California started the TML-usage ball rolling (*Chementator*, May 16, p. 69), seems very likely to prove conservative, observers say.

Chemical Goes to Market Via Piggyback Railway

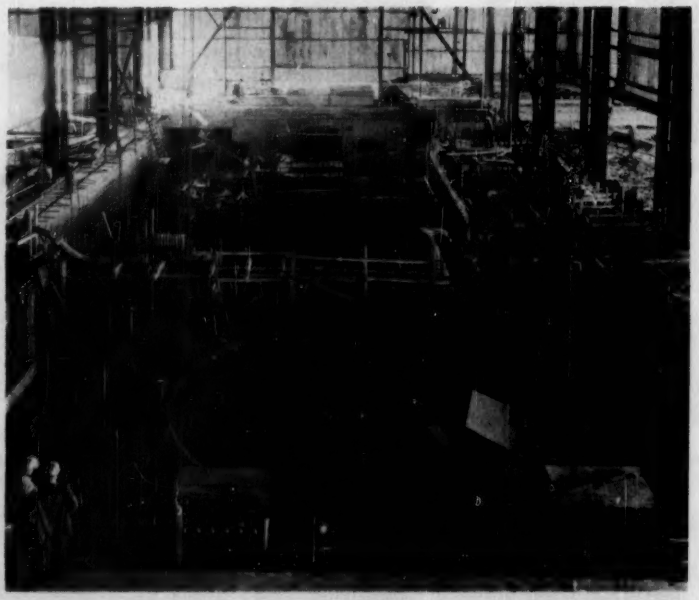
"Piggyback" rail shipment of tank trailers has come to the chemical industry.

Monsanto Chemical Co. (St. Louis, Mo.) reports that it has successfully completed the first such shipment ever tried on a liquid chemical product. Company last month delivered a 3,000-gal. order of *o*-dichlorobenzene to a New York area customer from its William G. Krummrich plant in St. Louis, Mo., via a tank trailer riding a railroad flat car.

Until now the piggyback rail transport of a chemical-loaded tank trailer has been considered impractical. Chief reason, notes Monsanto, is that "the shifting about of the tank's contents during yard switching and train motion might cause tipping and other damage." But Monsanto felt that the significant advantages of this form of transportation could be exploited by chemicals manufacturers if the "proper precautions" were taken.

Among the advantages cited by Monsanto are increased shipping speeds, thus ability to offer customers better service, elimination of costly handling, storage and inventory problems. The Nickel Plate Road railway company (New York, Chicago and St. Louis) offers the piggyback service to chemicals producers.

INDUSTRY NEWS



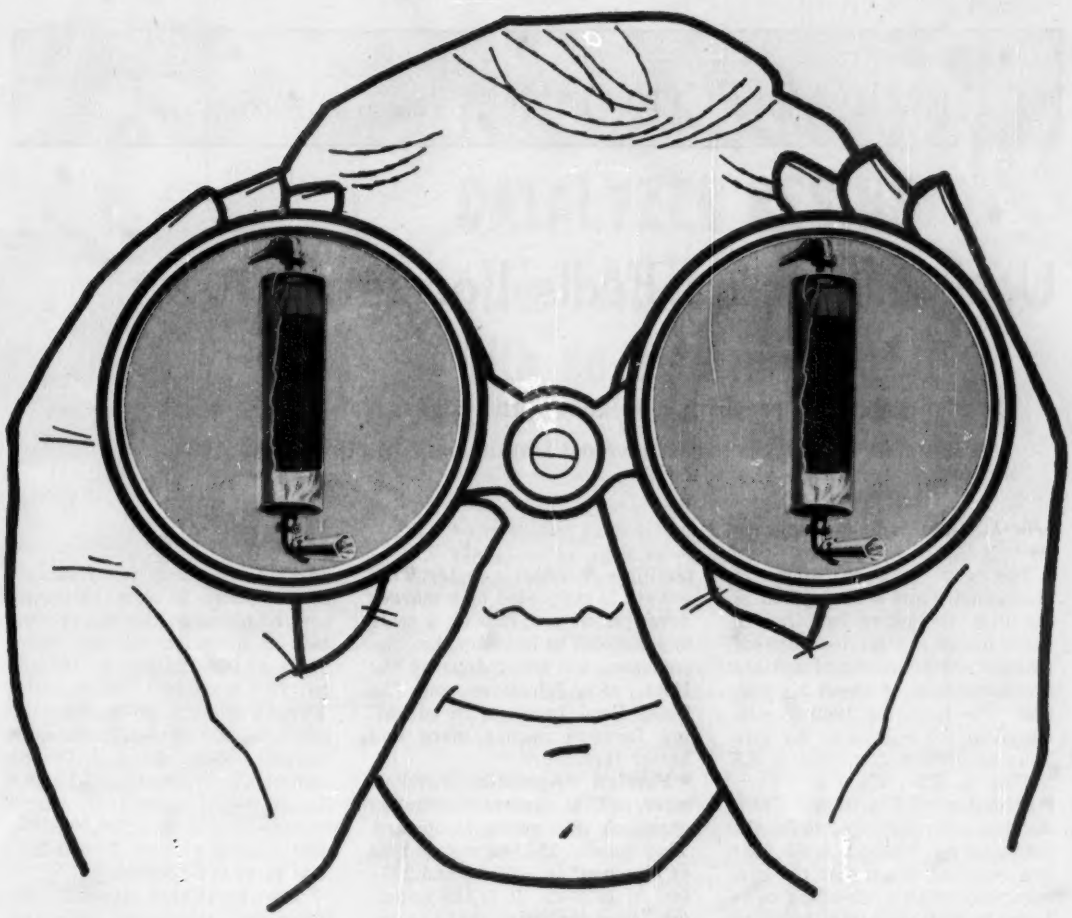
GAPING PIT, foreground, will house nuclear reactor at Hallam, Neb.

Consumers Public Power District of Nebraska will operate the 75,000-kw. nuclear power plant which can be seen taking shape above. To be known as the Hallam Nuclear Power Facility, the plant is part of the AEC's power reactor demonstration program and is scheduled for startup in 1962. It will use a sodium graphite reactor being built by Atomics International, a division of North American Aviation, Inc. The plant site is near Hallam, Neb.

Aluminum Co. of America recently started producing primary aluminum in a new, highly modern smelting works at Warrick, Ind. Company had delayed startup of the unit for over two years because industry-wide smelting capacity exceeded demand. The $80-million plant will eventually have five potlines (lines of electrolytic cells connected in series) which will be able to produce a total of 175,000 tons/yr. To date, however, Alcoa has completed and is operating only one potline, with a capacity of 35,000 tons/yr. A new coal-fired power plant, adjacent to the smelter, supplies electricity requirements; it is rated at 375,000 kw.

Humble Oil & Refining Co. has announced that it will increase butyl rubber production capacity at its Baytown, Tex., refinery. Present capacity is 125 million lb./yr.; new capacity will be over 170 million lb./yr. after the expansion is completed early next year. Company announced about seven months ago that it was upping butyl capacity at its Baton Rouge, La., refinery in a program to be finished by July 1961. When Humble completes expansion at both refineries, it will be able to make over 350 million lb./yr. of butyl rubber total combined output.

Industry News continues on page 168.



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1737

U. S. Ammonia Feels Foreign Impact

Demand is finally reaching a balance with supply. Now foreign markets are increasing in importance, yet low-cost imports are hurting in spots.

John A. King, Assistant Editor†

The gap between ammonia overcapacity and consumption in the U. S. is closing rapidly. In 1958, about 5.2 million tons of ammonia were produced against a consumption of about 3.8 million. The ratio for 1960 is estimated at 5.5 million to 4.7 million; projection for 1964 is 6.5 million to 6.2 million.

▶ **Stimulants**—Fertilizer production and consumption for the forthcoming 1960-61 crop year are expected to surpass the current year by 10%, cheering news both to the ammonia industry and to its biggest customer, the fertilizer-chemical industry. This growth is supported by a market development program on a scale unparalleled in industry, i.e., the enormous job being done by the Dept. of Agriculture and the Plant Food Institute in educating farmers to use more and better fertilizers.

▶ **Foreign Appetite**—Furthermore, in U. S. exports of nitrogen chemicals, the swing is upward. They totaled 180,000 metric tons of nitrogen* in 1955-56 and 205,000 in 1958-59. It is the underdeveloped countries that are importing the most for fertilizer consumption. In terms of metric tons of nitrogen, Spain's production-consumption balance went from 52,000-190,000 in 1955-56 to 70,000-220,000 in 1959-60; Egypt's went from 32,000-115,000 to 35,000-190,000 in the same period; Central and South America's from 60,000-164,000 to 100,000-310,000; India's from 80,000-145,000 to 100,000-260,000; Korea's from 20,000-132,000 to 90,000-250,000.

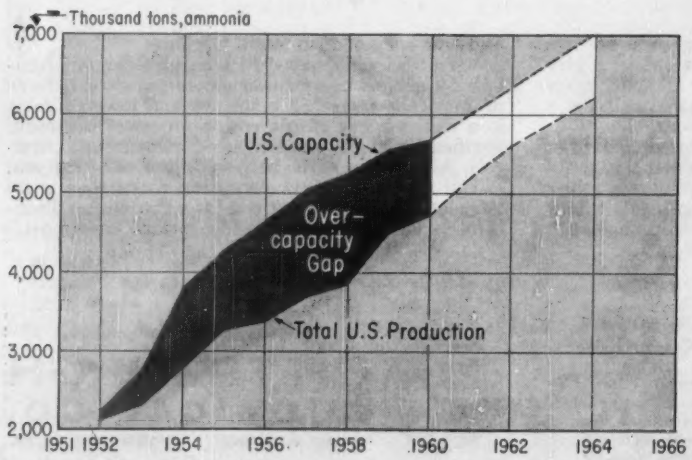
The insatiable appetite for nitrogen fertilizer chemicals created by India's vast population, for example, is evidenced in the country's Five Year Plans for industrial and agricultural development. Nitrogen chemical consumption will consistently surpass nitrogen chemical production. By 1965, production will be 840,000 metric tons, consumption 920,000; by 1970 the balance will be 1.44 million to 1.56 million; by 1975, if plans carry, India will be the third largest ammonia producer in the world, yet will be the largest importer of nitrogen chemicals.

▶ **Depressants** — In general, these stimulants are keeping U. S. ammonia prices stable in the $70-$75/ton range. In certain areas of the country, however, foreign producers and domestic co-ops are cutting prices.

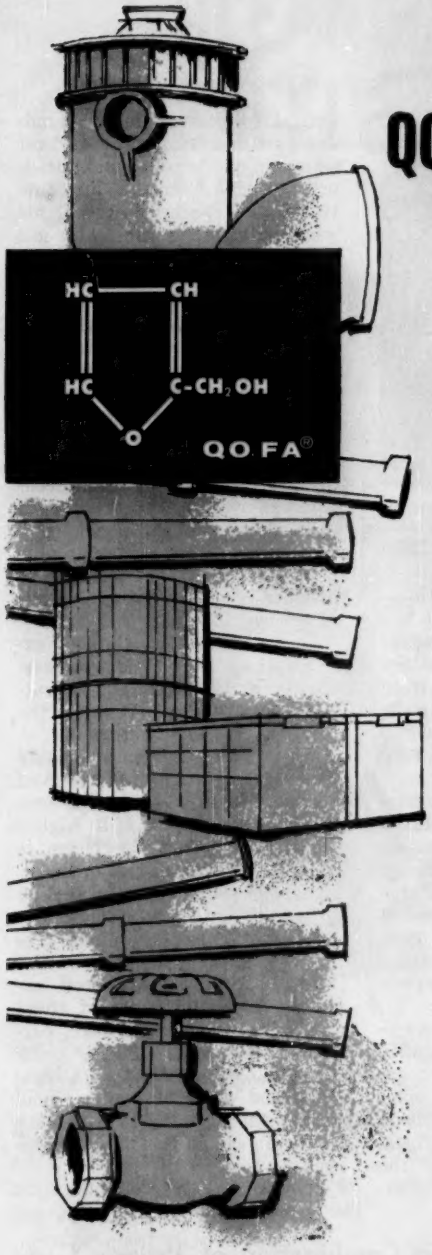
▶ **Far Eastern Competition**—According to a West-Coast industry spokesman, nitrogen imported from the Far East is being sold as low as $50/ton of ammonia. The explanation seems

† John King is now a technical editor for Vitro Laboratories, Silver Spring, Md.

* Because of its low value/ton, ammonia is not generally exported as such; usually calcium nitrate or urea or calcium ammonium nitrate is exported.



WAVE OF EXPANSION has finally passed its crest and big demand so far in 1960 promises that balance in supply and demand is not far off.



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If you have specific questions on FA resins, we would like the chance to provide the answers.

For general information, technical data, and uses about furfuryl alcohol write for Bulletin 205.

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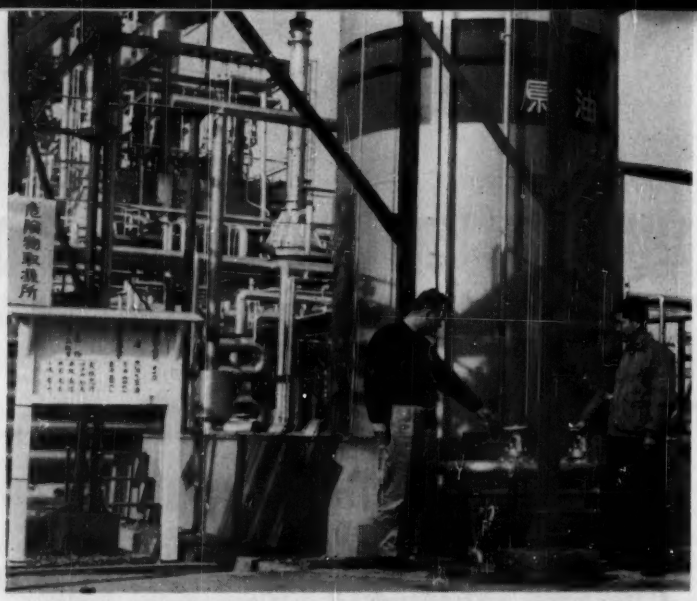

JAPANESE ammonia plant, evidence of new markets and competition for U. S. ammonia, was engineered by Chemico for Asahi in Nobeoka.

to be that foreign companies with current overcapacity choose to market their product at a low or even negative margin, rather than shut down their overcapacity. This spring, Korean tenders were running as much as 18% below the current going price for ammonia in the West Coast region. This foreign nitrogen chemical must be sold near its port of entry because its value is too low to be worth shipping great distances. However, a broader threat is made by current urea imports at $98/ton in a domestic market where the going rate is $105-$110/ton.

▶ **Co-op Competition**—Farm cooperatives are also having a depressing influence on market price and stability. In the Mississippi farm area, co-op prices for ammonia products in small quantity run as high as $80-$85/ton of ammonia. But with the farmer's stockholder return at the end of the year, amounting to as much as $14/ton, the actual ammonia price falls near $52/ton. Inability to meet this competition has already caused temporary shutdown to one plant.

Many industry spokesmen attribute the co-op's ability to sell at such low prices to its status as a non-tax-paying, non-profit organization and hope for Congressional action to stop what they believe is "unfair competition."

▶ **Technological Weapons**—These threats to price stability keep U. S. ammonia producers striving for the minimum combination of raw material costs, capital costs and operating costs.

Natural gas is currently the easiest to process, most abundant raw material. The earliest ammonia plants relied on byproduct hydrogen from chlorine-caustic plants. Later, large plants were built using the water-gas shift reaction. But since the early 1940's, most of the new plant builders have turned to natural gas, because the value of coke has increased past the point of practical use with the growth of the steel industry.

However, natural gas costs, which are on the upswing, may drive the hydrogen users to fuel oil sources. Anticipating eventual shortages or prohibitive natural-gas prices, some companies are already turning to processes versatile enough to produce hydrogen from any one of several sources.

Partial oxidation is a good example of such versatile processes. However, its capital and operating costs are higher than for the competitive steam-reforming.

Both processes unquestionably have a place in the future. And so do other processes that produce hydrogen at still higher costs. Their place, of course, is at plant sites where no ordinary hydrogen source, such as fuel oil or natural gas, is abundant.

India, because of its shortage of the usual hydrogen source materials, provides a good example of where some of these higher-cost processes are currently economic. There, coke-oven gas, coal or lignite gasification, and water electrolysis hold better than equal positions with natural gas and fuel oil as hydrogen sources.

Competition Keeps Producers Alert for Minimum Combination of Process Costs

U. S. Ammonia Capacity (by H_2 source)

	Thousand Tons/Yr.		
	1950	1955	1959
Steam Reforming	1,221.6	2,582.2	3,220.7
Partial Oxidation	...	429	749
Electrolysis	124	400.9	400.9
Catforming	...	36	60
Tail-gas Reforming	50	148.8	529.8
Other	590	705	580.4
Total	1,985.6	4,301.9	5,540.8

Utility Requirements (100 m. ton/day NH_3 Plant)

	Partial Oxidation	vs. Steam Reforming
Natural gas (process feed and fuel) Scfm.	2,200	2,350
Steam, lb./hr	1,550	1,700
Boiler feedwater, lb./hr.	7,000	8,500
Cooling water, lb./hr	3,500	5,000
Electrical power, kw	4,700	2,900

Capital Costs (NH_3 plants by H_2 source)

	$/Annual Ton of NH_3
Petroleum refinery byproduct hydrogen	112.00
Chlorine cell byproduct hydrogen	122.50
Byproduct hydrogen from natural gas processing	133.50
Natural gas	165.37
Fuel oil gasification	243.00
Coke oven gas	264.00

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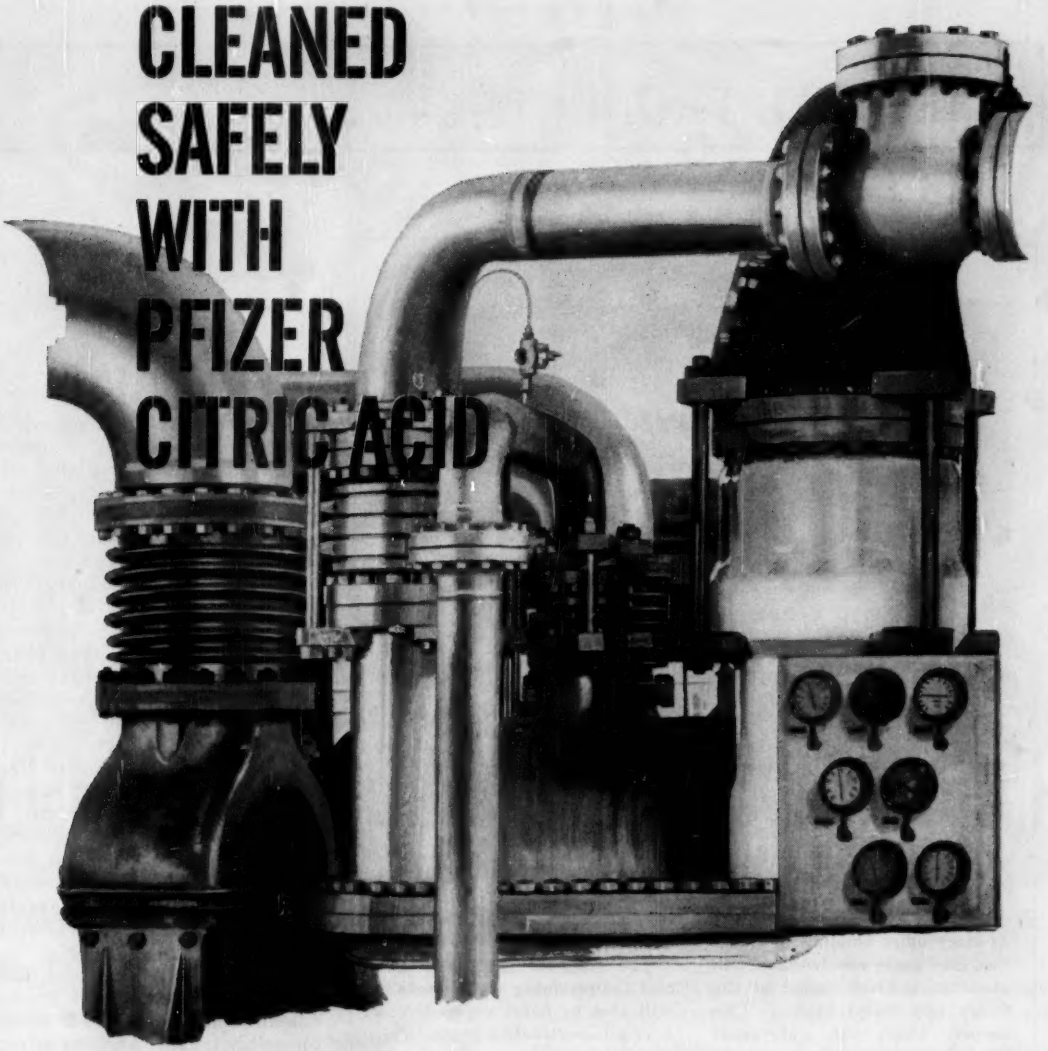

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● Industry experience proves that citric acid eliminates chloride stress corrosion problems — provides effective descaling — permits easier, more efficient after-rinsing.

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1 Citric acid is highly efficient in removing imbedded metal and oxide films from stainless steel.

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3 Citric acid cleaning eliminates the problem of chloride stress corrosion.

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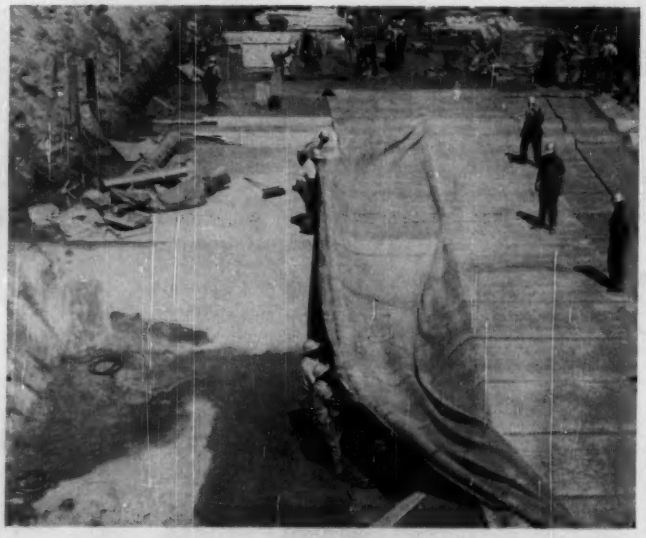


Butyl Blocks Out Water for Skyscraper Foundation

Humble Oil & Refining Co.'s 44-story office building in Houston, now under construction, will stand on a black carpet of the firm's own butyl rubber. This carpet, which will waterproof the building foundation, possibly represents the most unique use found to date for the petrochemical elastomer.

The butyl sheeting, ⅛ in. thick, is being placed over a thin concrete seal slab at an elevation 60 ft. below ground level. On top of it will be placed a reinforced concrete slab 7 ft. thick.

The sides of the thick slab and the retaining walls above it will also be butyl encased. The over-all construction project (including an adjacent garage) will use about 230,000 sq. ft. of the sheeting.

Company states that the exterior application of butyl is less costly than most conventional methods of creating a water barrier.—Humble Oil & Refining Co., Houston. 86A

Primers

Red primer dries quickly; white primer resists alkali.

Two new primers, each aimed at specific, different applications, have recently been announced. The first, produced by Reilly Tar & Chemical Corp., is a synthetic red primer designed for use in difficult drying and aplication conditions. The second, Tropical Paint Co.'s rubber-base primer, is designed for use in places subjected to moisture condensation, fumes and mildew growth.

▶ **Redhead** — Reilly's product, tradenamed Reilly Redhead, is a solution of selected synthetic resin dissolved in a suitable organic solvent blend. It contains a maximum of 2% by weight of a red organic coloring material, but no filler.

A distinguishing feature of the brilliant red primer is its ability to dry to touch within 10 minutes, when applied by brush or spray to prepared clean metal surfaces at the rate of 500-800 sq. ft. per gal.—provided the atmosphere is about 70 F., relatively dry and free from organic solvent vapors. Under the same conditions, it will be dry enough to accept an enamel coating within two hours. Initial bond strengths are up to several times greater than those of typical nonsynthetic primers.

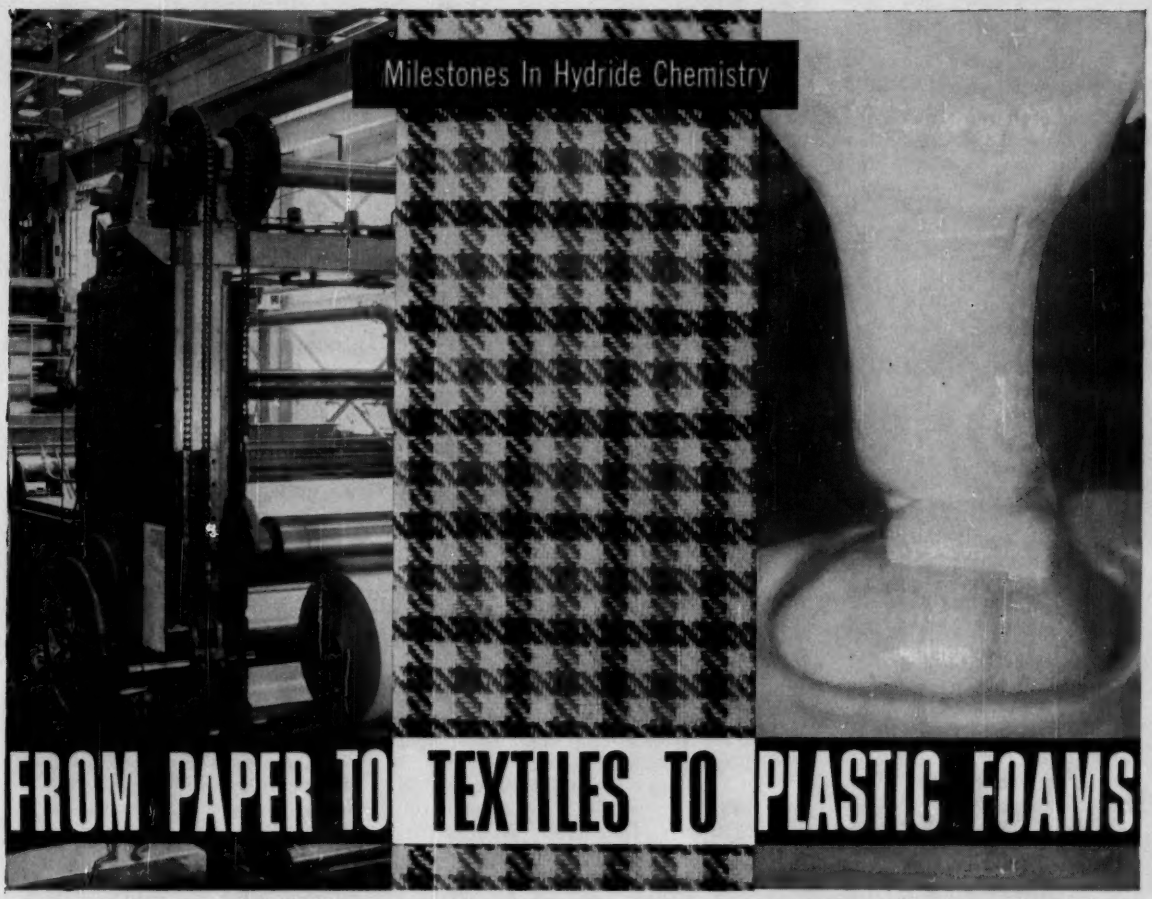
If enameling is delayed, Redhead primer film will protect clean metal surfaces for weeks, possibly longer. Another advantage is the red color, which permits the operator to see that the prime coat completely covers the metal surface and to detect areas not covered in enameling.

Redhead is available in 55-, 5- and 1-gal. containers.—**Reilly Tar & Chemical Corp., Indianapolis.** 86B

▶ **White Primer**—Chemical Resisting White Primer, Tropical Paint's new rubber-base product, is expected to find wide use in dairies, chemical plants, bottling plants, breweries, institutional kitchens and any room subjected to water condensation, fumes and mildew.

As an alkali-resisting primer, it's an excellent sealer on new plaster, masonry and hard board. And it's also suitable for priming unpainted iron and steel surfaces.

The primer is intended for



New Processing Applications for Borohydrides

In league with chemical processors around the world, MHI continues full tilt on the development of new applications for hydride chemistry. Application development for sodium and potassium borohydrides, for example, has opened exciting possibilities for chemists working in the pulp, paper, textile and plastic foam fields.

Reductive wood pulp bleaching

Sodium borohydride and potassium borohydride are being used effectively as reductive bleaching agents for wood pulp and cellulosic textile materials and for stabilizing bleached materials to prevent color reversion or yellowing. For the first time, chemists now have a water soluble reagent which will selectively and quantitively reduce the aldehyde groups in oxidized cellulose.

Textile finishers "clean up"

The borohydrides quantitively and rapidly reduce aldehydes and ketones to alcohols in water or alcoholic solutions at room temperature and atmosphere. The borohydrides "clean up" trace amounts of residual aldehydes in organic products, preventing odor development and greatly improving color stability for finishes using aldehyde-based resins. Borohydrides also reduce the carbonyl group in cellulose, introduced by oxidative bleaching, thus increasing resistance of the fibers to hot alkali.

Borohydrides make better foams

Borohydrides for producing vinyl foams offer versatile and inexpensive process possibilities using simple equipment. As blowing agents, the hydrogen yield of the borohydrides produces foams of fine, uniform cellular structure. Foam density is variable with the concentration of the borohydride. In addition to fine uniform cell structure, other advantages include low density, and low compression set.

New literature-technical service

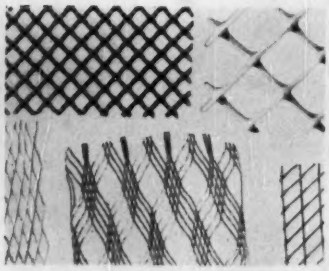
Qualified technical service in applying the borohydrides to your process is available without obligation. If you do not now have these new MHI literature releases, write for copies now!

PIONEERS IN HYDRIDE CHEMISTRY

Metal Hydrides Incorporated

711 WEST CONGRESS STEREET, BEVERLY, MASSACHUSETTS

use under Tropical Paint's Chemical Resisting Glass White Paint. — **Tropical Paint Co., Cleveland.** 86C



Thermoplastic Netting

Polymers extruded in tubular net form.

Two new versions of thermoplastic materials offer design engineers a variety of rigid or flexible colored net sheeting and tubing for applications ranging from fish nets to chemical filter cores.

The new materials are Vexar plastic netting and piping, made by an exclusive process that extrudes polymers directly in tubular net form in a single operation. By this technique each strand intersection becomes an integral part of the material, in contrast to die-cut, interwoven or heat-sealed netting or tubing where the openwork pattern is made after the material is extruded.

The patented British development was acquired by Du Pont last year. Although Du Pont is still developing the material further, the company announces that commercial quantities of Vexar made from polyethylene are now available.

Main advantage of the new materials is their great variety in mesh size and pattern, filament diameter, strength, stiffness and color. Also, the products retain the chemical and physical characteristics of the basic plastic resin.

Strand diameters can be made from 15 mils up; mesh size can be varied from 16 counts/in. to more than an inch between strands.

Three basic patterns, diamond, twill or plaid, are available in most Vexar plastic netting or piping products.

Early commercial applications include: semi-rigid piping, for protective sleeves over polished tubular machine parts; heavy-gage rigid piping, for center tubes of cylindrical liquid filter cores; and thin-gage flexible tubular netting for packaging.—**E. I. du Pont de Nemours & Co., Wilmington, Del.** 88A

Liquid Urethane

Eutectic mixture for solvent, raw material uses.

A new urethane mixture, Liquithane, promises to find use as a solvent for organic compounds and as a raw material for high-molecular-weight carbamates, new chemicals and polymers.

A eutectic mixture of 52% ethyl and 48% methyl urethanes, Liquithane is a colorless, almost odorless liquid. Under 20 mm. Hg it boils at 90 C.; under atmospheric pressure it boils (with decomposition) at 177 C. Its equilibrium melting range is 13-17 C., and it is miscible with water and most organic liquids other than saturated aliphatic hydrocarbons.

Liquithane's manufacturer suggests that it can be used as a solvent for recrystallization, polymer processing, paints and lacquers, and as a coupling agent and paint stripper. Dichlorophosphoryl isocyanates, made from Liquithane and phosphorus pentachloride, can be used in modified methane polymers and flame-proofing compounds.—**Millmaster Chemical Corp., New York.** 88B

Modified Rubber

Withstands low temperatures without hardening.

When ordinary natural rubber is vulcanized and stored at low temperatures it tends to progressively stiffen and lose elastic properties, because of the regular orientation of the rubber molecules.

Now, by chemical change, an English group has modified the carbon "spinal column" of natural rubber just enough to prevent this orientation from tak-

Newsworthy Chemicals

Page Number is also Reader Service Code Number

Butyl rubber carpet protects building foundation..... 86A
Red primer dries fast on metals..... 86B
White primer withstands alkalis, mildew..... 86C
Thermoplastic netting extruded directly..... 88A
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Gamma phenoxybutyric acid ready for customers..... 90D
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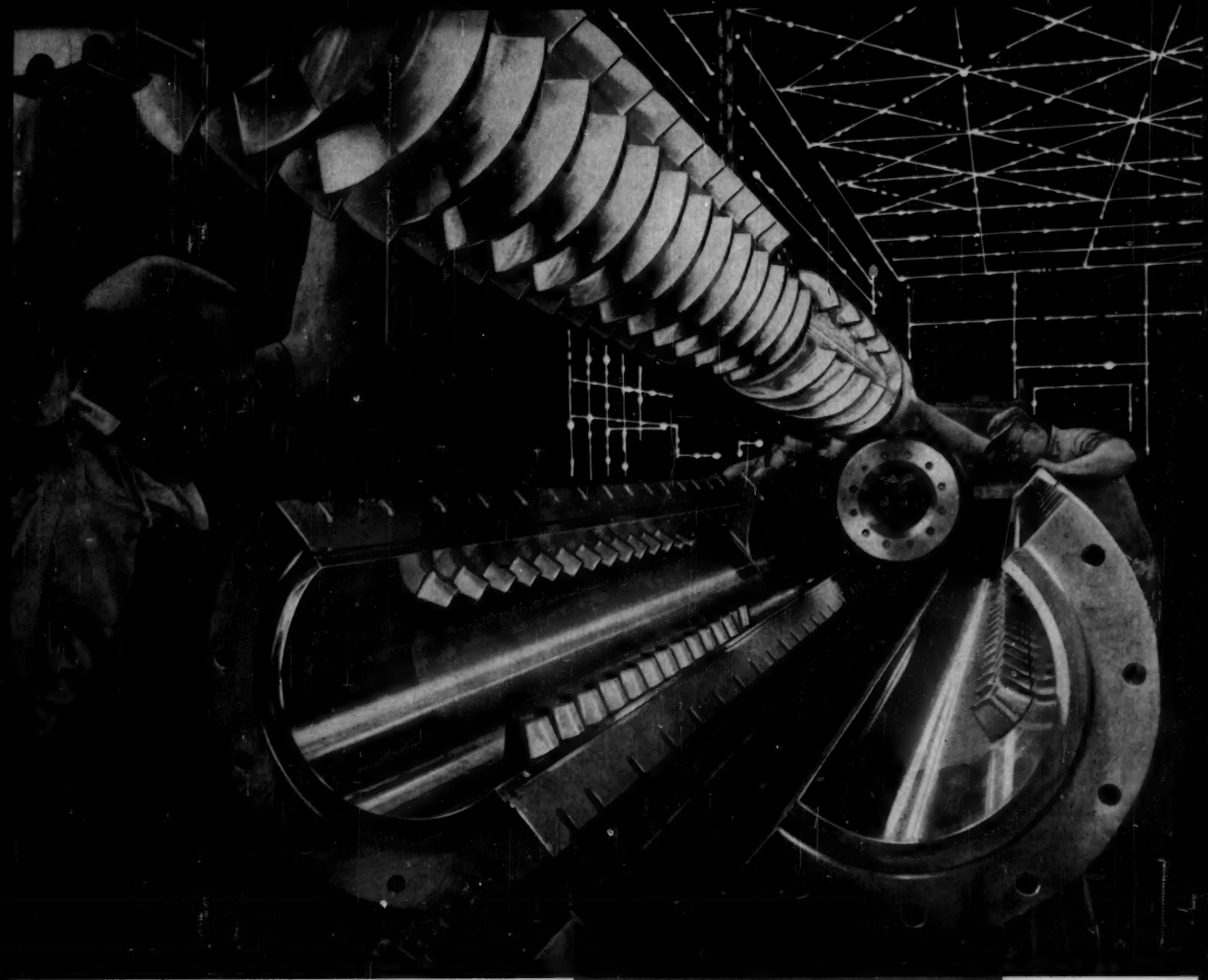
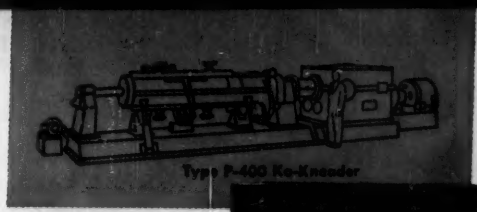
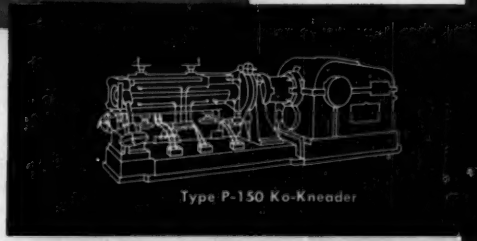
Oxazoline waxes can be used to replace other waxes..... 90G

For more details, use Reader Service Card



B·P
KO·KNEADERS (LIST SYSTEM)


Type P-400 Ko-Kneader


Type P-150 Ko-Kneader

precision built for efficient continuous mixing

Precision built and skillfully engineered Baker Perkins Ko-Kneaders will convert your inefficient batch process to faster, more continuous operations. Less floor space is required and maintenance costs are materially reduced. With a Ko-Kneader, you not only get more production at less cost, but you give your customer a superior product, too.

B-P Ko-Kneaders are now mixing a wide variety of products such as plastics, carbon electrodes, food specialties, floor tile, solid rocket propellant fuels and many others. From this experience, proper recommendations can be made for your operation. However, if a new mixing problem is involved, test demonstrations can be arranged in the Baker Perkins Laboratory. Write today for engineering manual K-57 or contact your nearest Baker Perkins sales engineer.

BAKER PERKINS INC. CHEMICAL MACHINERY DIVISION
SAGINAW, MICHIGAN

ing place. The result: A rubber that stiffens as much as 1,000 times slower than normal natural rubber, and that can remain effective at temperatures below −60 C.

The new product, called Anti-Crystallizing Natural Rubber, can be produced by modifying natural rubber with thiolbenzoic acid or sulfur dioxide. A commercial process has been devised using the latter. Since sulfur dioxide itself is a gas and difficult to handle, a solid, butadiene sulfone, is mixed into the rubber. When the mixture is heated for a few minutes, SO_2 is released from the butadiene sulfone and immediately produces the desired rearrangement of the rubber molecule.

The new development thus produces a natural rubber for applications connected with high-flying airplanes, deep-freeze equipment, industrial and military items for northern climates, and similar sub-zero usages. — **Natural Rubber Bureau, Washington, D. C.** 88C

Polyester Ductwork

Ingenious operation replaces corroded iron ducts.

When corrosion hit the galvanized ductwork in a Cleveland plating plant, it seemed necessary to tear down and replace the duct system.

Rather than resort to this solution, the plant maintenance department covered the duct system with glass-reinforced polyester—using the old ducts as mandrels on which to form brand new pipe.

The technique, suggested by Heil Process Equipment Co., involved four steps. First, the old corroded ductwork was painted with Atlac 382, a polyester resin. Then a layer of glass mat saturated with the resin was placed around the ducting. Another saturated mat was applied, followed by a finishing coat of resin. A total of 2,500 ft. of ductwork was covered with glass-reinforced polyester in this way, with diameters varying from 6 in. to 18 in.

The old, corroded, galvanized iron ductwork is now completely ignored. Particles from the corroded ducts will be removed through the ventilating system, and eventually an extremely strong, corrosion-resistant polyester-glass pipe will comprise the ductwork. — **Atlas Powder Co., Wilmington, Del.** 90A

BRIEFS

1,4-Dioxane, which until now has been produced by Dow for its own use, is currently available in commercial quantities. A cyclic ether, the dioxane is used as a stabilizer for chlorinated solvents; as a solvent for cellulosic plastics, natural resins, mineral and vegetable oils; and as a wetting and dispersing agent, dyeing aid or extraction agent for textiles.—**Dow Chemical Co., Midland, Mich.** 90B

Indicating liquids for manometers and hydrostatic gages are color-coded in seven different colors. Liquids range in specific gravity from 0.824 to 13.546 at 68 F., giving wide choice of instrument sensitivity and range. Gravity of each liquid remains constant to third decimal place, thus fostering dependable measurement. To avoid confusion and errors in measuring, each liquid has its own distinctive color—orange, blue, green, purple, brown, red or silver.—**King Engineering Corp., Ann Arbor, Mich.** 90C

Gamma phenoxybutyric acid and other gamma butyric derivatives have been added to line of substituted propionic acid derivatives. Gamma acid and two derivatives, γ-2,4 dichlorophenoxybutyric acid and γ,γ-dithiodibutyric acid, are available in development quantities. Products suggested for use as weed killers, metal deactivators and intermediates. — **Aceto Chemical Co., Inc., Flushing, N. Y.** 90D

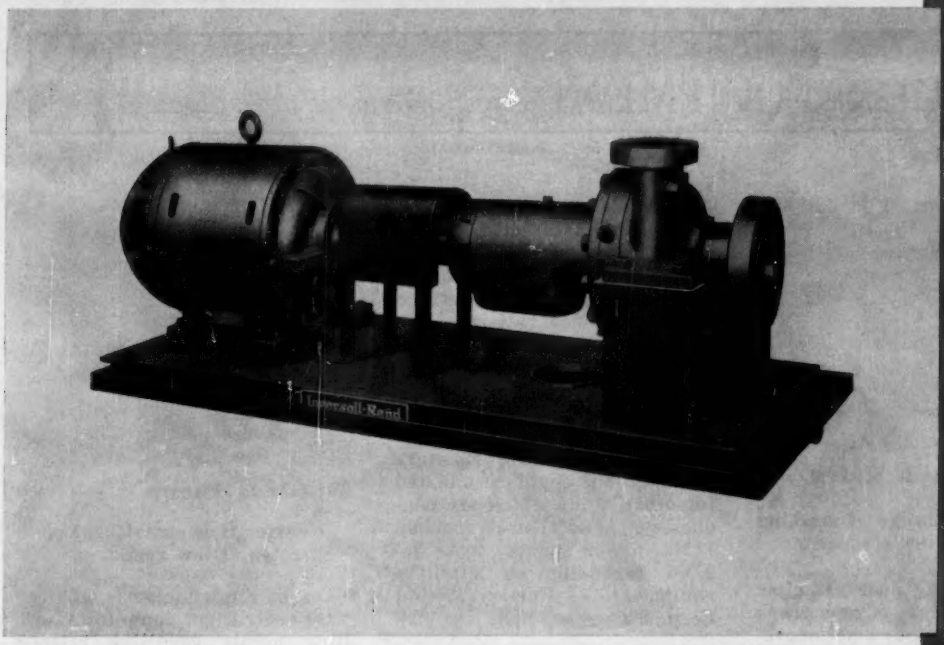
Three organics, nicotinic (carboxyl-C-14) acid, nicotinamide (carbonyl-C-14) acid and phenanthrene-9-C, have been added to the list of over 225 available compounds tagged with radioactive carbon. Labeled nicotinic acid and nicotinamide acid will aid in better understanding the function of these acids in metabolic processes. Tagged phenanthrene will be used in hormones research. — **Nuclear-Chicago Corp., Des Plaines, Ill.** 90E

Ceramic coatings—e.g., a vitreous type bonded refractory in which ziron is bonded with a high-temperature glass—protect high-temperature structural strength of tungsten at temperatures of more than 3,000 F. Process enables efficient use of tungsten's high-strength properties in such applications as space vehicles. —**American Ceramic Society, Columbus, Ohio.** 90F

Oxazoline waxes, derived from nitroparaffins, impart unusual adhesion, lubricity and wettability. They are suggested wherever natural or synthetic waxes are used. Two versions are commercially available: TX-1, a hard, high-melting, emulsifiable, rosin-like wax; and TS-254, a hard, medium-melting, emulsifiable wax.—**Commercial Solvents Corp., New York.** 90G

For More Information about any item in this department, circle its code number on the **Reader Service** postcard (p. 201)

● **The latest addition to Ingersoll-Rand's extensive Process Pump Line**



NEW *Centerline mounted* Process Pump with integral Mechanical Seal for heads to 650 ft., temperatures to 250° F.

Ingersoll-Rand introduces a pump that is designed around the modern concepts of integral mechanical sealing, centerline mounting, ease of operation and maintenance *at lower first cost.*

Designed for handling light refinery liquids such as oils, LPGs, distillates and solvents, these pumps feature an integral single mechanical shaft seal which efficiently stops liquid losses and reduces stuffing-box attention to a minimum. The seal can be arranged for internal or external circulation. The casing is cast steel and is arranged for end suction and top discharge.

Complete Range of Sizes – The line includes 1, 1½, 2, 3 and 4 inch units with 14 basic impeller sizes covering a range of capacities to 1400 gpm and heads to 650 ft. Maximum working pressure is 400 psig. Maximum working temperature is 250°F.

Thoroughly Proven Design – Ingersoll-Rand introduced the Industry's first process pump with a built-in seal as standard equipment in 1951. All of the proven design features have been incorporated in these pumps.

Rugged, Long-Life Construction – Designed for moderate pressures and temperatures of many modern refining, petrochemical and chemical processes. A short rugged shaft, heavy-duty angular contact thrust bearing and deep groove radial bearing provide a rugged design that means long pump and seal life.

Maximum Parts Interchangeability is provided throughout the complete line. In addition, parts are interchangeable with most other types of Ingersoll-Rand vertically-split process pumps thereby greatly reducing spare part inventories.

Your nearest Ingersoll-Rand engineer will be glad to tell you more about these new pumps and help you select the best unit for your application. Ingersoll-Rand makes the world's most complete line of process pumps. There's one that's *right* for you.

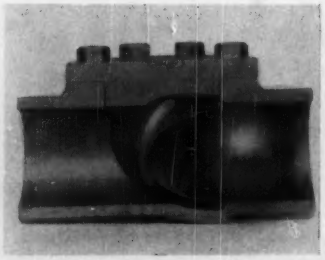
Ingersoll-Rand

10-986 ♥ 11 Broadway, New York 4, N. Y.

COMPRESSORS • GAS & DIESEL ENGINES • PUMPS • AIR & ELECTRIC TOOLS • CONDENSERS • VACUUM EQUIPMENT • ROCK DRILLS

DEVELOPMENTS . . .

PROCESS EQUIPMENT EDITED BY FRED PRICE



Hinged Check Valve

Allows passage of marking balls or line scrapers.

The swinging door principle is the key feature of new check valve which passes batch-marking balls or conventional line scrapers. Valve has side-hinged clapper which recesses completely into the valve body to allow full ID opening.

When the ball or scraper enters the valve it contacts the clapper which floats on thrust bearings and is controlled by a one-piece hinge pin. Clapper is hinged on an 8-deg. angle to reduce dead-weight resistance, eliminate sticking and jamming.

Dubbed Sphere-Clear, valve comes in 1 to 36 in. sizes in steel, semi-steel, and aluminum bronze.—**Frank Wheatly Pump & Valve Mfgr., Tulsa, Okla. 92A**

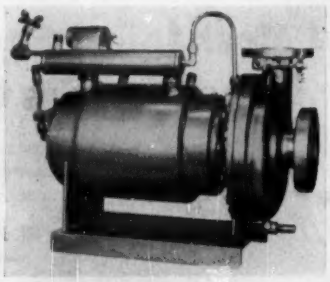
Moisture Gage

Continuously measures and records product moisture.

If solids flow in pipe, chute, conveyor or bin, Aquatel can measure their moisture content. Unit sensing head is part of a continuously balanced a.c. capacitance bridge. Electrical resistance of flowing product unbalances the bridge so that the resistance component needed to rebalance is a direct function of the moisture.

Recorder, which may be remote from the sensing head, may be used either to indicate or record, or can actuate signal if moisture exceeds set limits. Value is read directly in percent. Sensing head, only a few inches long, can be mounted flush with pipe or chute surface for unbroken flow pattern.

Unit has been used in pipes up to 8 in. dia. to temperatures of 300 F. Velocity of flowing material does not affect reading in usual applications. Unit is designed to measure moisture as water but could be adapted for other fluids which are conductors. Aquatel uses common 115-v. power source, costs $6-9,000 depending on auxiliary equipment. — **Curtiss-Wright Corp., Princeton, N. J. 92B**

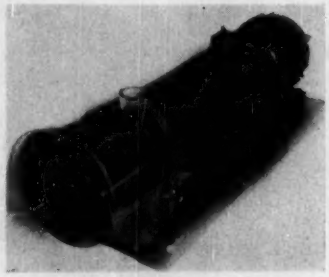


Canned Pump

High temperature unit has external heat exchanger.

Sealless canned pump can handle higher temperature fluids with externally mounted heat exchanger. As in other canned units, part of the pumped fluid circulates through the motor section between the rotor and the stator. In new pump, fluid, which is both motor coolant and bearing lubricant, circulates continuously through the heat exchanger and motor section.

Also, model has a water cooled jacket around the motor section to give additional heat removal. Canned pump advantage of no stuffing boxes or seals is retained in heat-exchanger unit.—**Fostoria Corp., Huntingdon Valley, Pa. 92C**



All-Glass Pump

Vortex type centrifugal operates at low rpm.

Out of England comes an all-glass centrifugal pump for handling highly corrosive materials. Inlet piping, impeller and housing, and discharge piping are glass with a special mechanical seal on the impeller shaft. Secret of the seal is a spring-loaded, glass-faced bellows which presses against a glass seal plate while rotating on the impeller shaft.

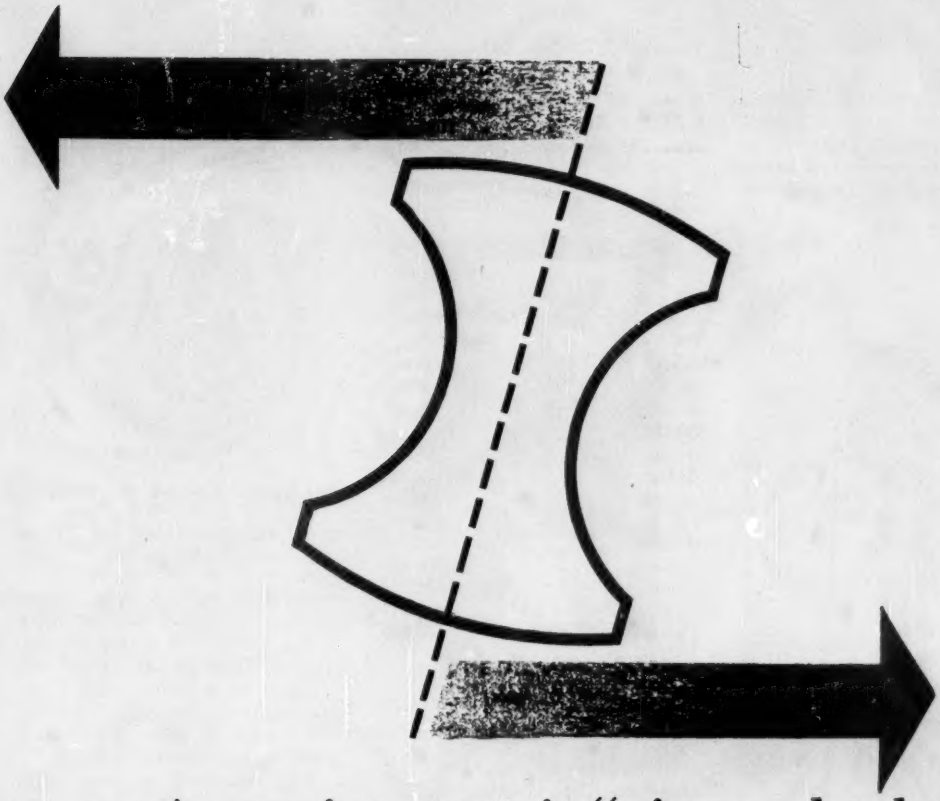
Two models in the line operate at 1,440 rpm., pump from 10 to 100 gpm. at 20 to 25 ft. head. Approximate cost in U. S. A.—$1,400.—**Q. V. F. Ltd., Staffordshire, Eng. 92D**

High Temperature TC

Tungsten unit gives reliable readings up to 5,000 F.

Suitable for use in vacuum, hydrogen, or inert gases, thermocouple made of tungsten-tungsten 26% rhenium pair is accurate up to 5,000 F. Although recommended for use above 3,500 F, TC has high output which makes it useful in lower ranges. For normal applications, no corrections are needed for cold junction temperatures between 30 and 70 F.

Couple should not be used under oxidizing conditions or in the presence of hydrocarbon vapors, which attack tungsten above 2,000 F. Voltage output



An assignment in "give and take"... for Lukens Application Research.

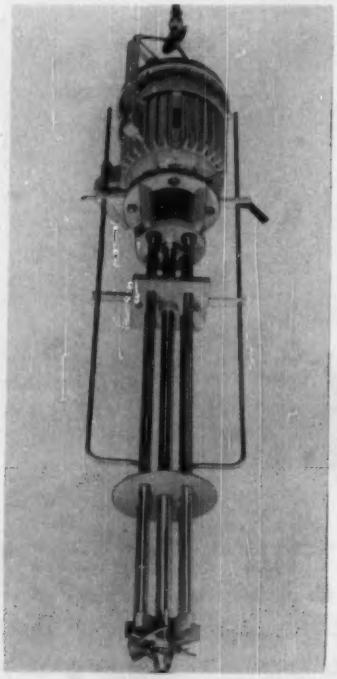
Researching the steel that best fits the job is a matter you can safely trust to Lukens Application Engineers . . . whether your problem is metal expansivity, cryogenics, abrasion, structural stress or the complexities of corrosion. A recent and typical assignment was to determine the most efficient material on which to cradle the bearing members of a bridge. These mechanisms provide the "give" that keeps a bridge structurally sound. Since corrosion-resistance was a major goal, stainless steel seemed well-suited—but costly. Lukens, with its broad fund of practical metallurgical knowledge, suggested—then thoroughly tested—the less expensive stainless-*clad* steel. The success of this engineered combination of clad and backing steel has since been borne out by a host of clad steel bearing plate applications.

If you have an assignment in metals application, let it be our assignment too. Also contact us for Bridge Bearing Plate Bulletin. Write Manager, Application Engineering, Services Building, Lukens Steel Company, Coatesville, Pennsylvania. Address Dept. H-70.

HELPING INDUSTRY CHOOSE STEELS THAT FIT THE JOB

LUKENS STEEL

conforms to standard calibration curves within ±1% for all couples. Individual units reproduce readings even more accurately. — **Engelhard Industries, Newark, N. J.** 92E



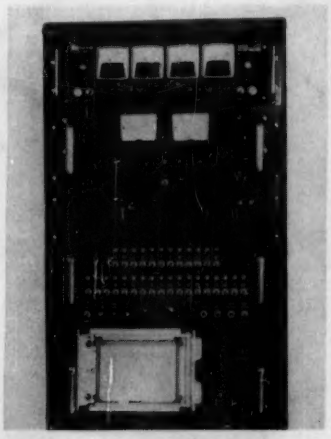
Turbine Mixer

Converts quickly from open to closed turbine mixing.

A new line of versatile turbine mixers features easy conversion from open to closed type or vice versa. Mixers draw in material and force it upward through jet openings in the head without forming a vortex and without incorporating air, according to the manufacturer.

Operator can change the space between the rotor and stator to increase or decrease the degree of shear and impact to which the material is subjected. For handling viscous, gelatinous, or highly thixotropic materials, he removes the stator sleeve and operates the unit as an open turbine mixer.

Models range from ½ to 15 hp. with capacities of 3 to 3,000 gal. Shaft speeds vary from 8,000 in smaller to 3,000 rpm in larger units. Contact metals are stainless steel to minimize contamination.—**Barrington Industries, Inc., Providence, R. I.** 94A



Solid-State Monitor

Verifies the condition of 30 stations within 1 sec.

Signal Sentry, an all solid-state monitor-alarm system, can examine signals from 30 channels and determine in a fraction of a second whether they fall within prescribed limits. Accuracy is 0.1%.

Signals from transducers representing temperatures, pressures, liquid flows or displacements are fed to the alarm system. Allowable values for each station are punched on a card. When card is inserted, unit checks each station against prescribed values and signals when a station has exceeded (or is about to exceed) allowed tolerance—all within 0.3 sec.

Requiring less than 30 w. of power, unit is less than 42 in. high, and occupies under 12 cu. ft.—**Franklin Electronics Inc., Van Nuys, Calif.** 94B

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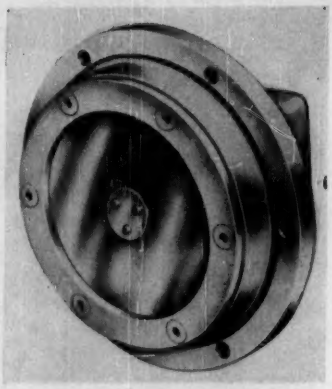
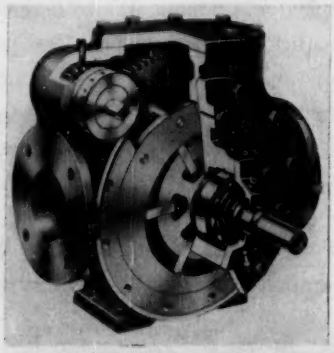


Hopper Level Switch

Explosion-proof unit can control bin feeder.

Material in bins, hoppers, or chutes is under control with new level switch which mounts directly through the vessel wall without an adaptor ring. Compact unit is particularly suited for small hoppers or vessels with limited mounting space.

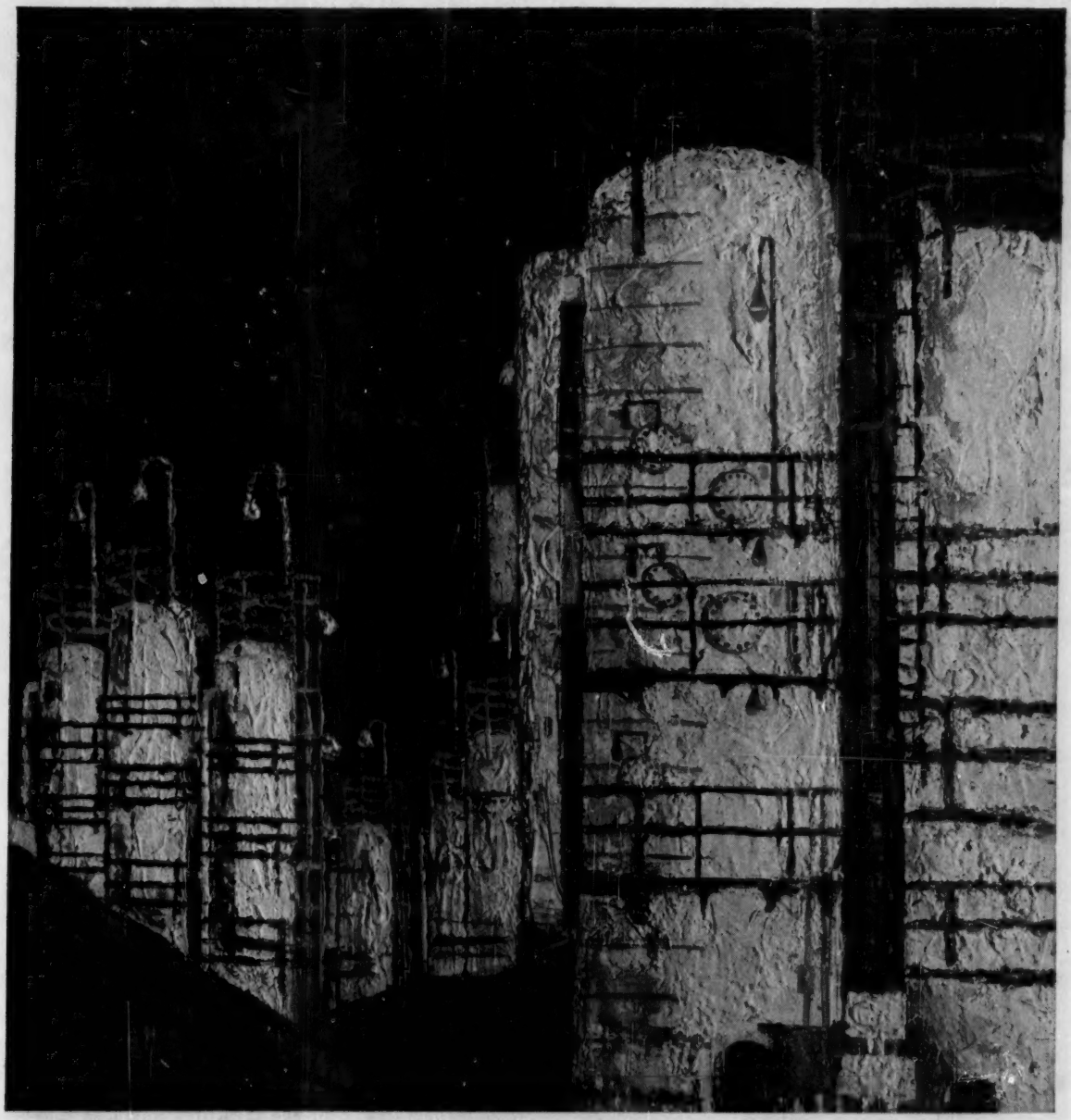
Unit may be equipped with one or two switches for operating relays or feeding devices, hence can automatically control the bin level by feeding into or out of it.—**Syntron Co., Homer City, Pa.** 94C



Multi-Capacity Pump

Dial setting gives any rate at constant pump speed.

Dial the flow rate you want with new variable-capacity rotary pump—and change it anytime while the pump is running. Called Vari-flo, pump can give any rate from zero to 450 gpm. without changing pump speed.



More drying per dollar in nine towers showed Columbia Gulf Transmission why it pays to

mix imagination with Alcoa Aluminas

Nearly ½-million lbs of Alcoa® Activated Alumina is giving Columbia Gulf Transmission Co. maximum drying capacity per dollar in one of the world's largest natural gas drying operations. Used in nine towers at the company's Rayne, Louisiana, compressor station, the activated alumina dries 690 MMSCF of natural gas per day. Average water content of gas entering the towers is 5-6 lbs water/MMSCF. Water content of the effluent gas is below ½ lb water/MMSCF. Each tower is on stream for 24 hours with a reactivation time of 6 hours. Columbia Gulf Transmission has found that no other desiccant can furnish such efficient drying at such low cost.

When effective, economical drying is your aim, it pays to mix imagination with Alcoa Activated Aluminas—the oldest commercial desiccant available and still the most efficient. For detailed data, send for a free copy of the Alcoa White Data Sheets and a comprehensive Gas and Liquid Dehydration Questionnaire. Aluminum Company of America, Chemicals Division, 706-G Alcoa Building, Pittsburgh 19, Pa.

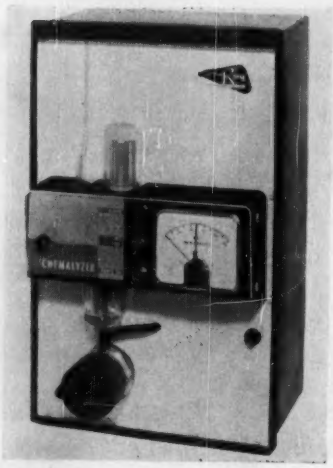
ALCOA CHEMICALS
ALUMINUM COMPANY OF AMERICA

For finer products . . . let Alcoa add new dimension to your creative thinking!

Flow also can be reversed to evacuate discharge lines.

Heart of the variable nature of pump is an eccentric liner which is rotated by the dial. At full capacity, liner seals to the rotor; at lower capacities part of the fluid recycles within the pump. At zero flow, displacement above and below the rotor is the same, hence no flow. Rotating liner a little further causes net flow reversal. The eccentric liner technique works because the rotor has sliding self-compensating vanes.

Pump is best suited for following applications: Filling tanks or drums at successively lower capacities, pumping liquids whose viscosity changes as a tank is heated, and proportioning liquid streams. Pump comes in 2, 3, and 4 in. sizes.—**Blackmer Pump Co., Grand Rapids, Mich. 94D**



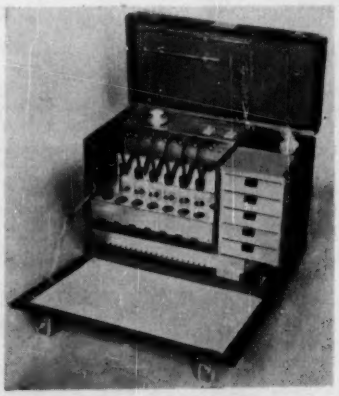
Automatic Analyzer

Photoelectric comparator uses colorimetric means.

Continuous on-stream monitoring of hardness, residual chlorine, or phosphates is possible with Chemalyzer, an instrument incorporating photoelectric comparison in colorimetric analysis.

Unit has three main uses: to sound alarm or start regeneration cycle if hardness breakthrough occurs on water softener system, to warn the operator of high or low chlorine concentrations on cooling tower water, and to start feed pump to maintain phosphate level in boiler water.

Chemalyzer has an indexing motor which proportions exact amount of reagent with a fixed sample volume at pre-set intervals. Accuracy range: hardness, 3 ppm.; residual chlorine, 1 ppm.; residual phosphates, 30 ppm. System is applicable to other one-reagent colorimetric analyses. Cost: under $1,000.—**Milton Roy Co., Phila., Pa. 96A**



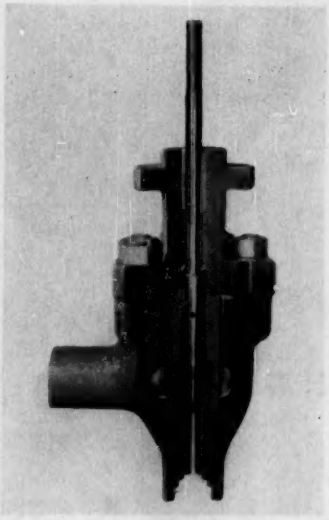
Portable Air Tester

Measures eighteen gaseous and particulate pollutants.

A new, compact, portable apparatus for air pollution testing makes it easier to cope with air pollution laws and to check on possible pollution in emergency situations.

Simple enough to be operated by non-technical personnel, unit consists of a train of reagents and color solutions through which the air is pumped. Colors developed by the unknown sample are compared against color standards which have previously been calibrated in terms of the various pollutants.

Apparatus, which works off a 12 v. d.c. supply, can detect nitrogen dioxide, hydrogen fluoride, chlorine, sulfur dioxide, oxidants, ammonia, formaldehyde and hydrogen sulfide among the gases. It also finds particulate pollutants including mercury, lead, copper, chromate, selenium, iron, nickel, arsenic, phosphate and sulfate. Cost: $595.—**Central Scientific Co., Chicago, Ill. 96B**



High-Pressure Valve

Designed for quick change of exposed internal parts.

Pressure drops up to 3,500 psi. are handled by new low-noise throttling valve for high-pressure liquid and steam. Valve trim (internal parts which contact fluid) may be replaced in minutes without opening line piping, according to the manufacturer.

V-10 line has flow parallel to internal valve surfaces to reduce impingement. A diffuser section on the seat and contour of the throttling surfaces combine to protect the valve body by limiting erosion and cavitation to the trim components. Trim may be selected for linear, equal-percentage, straight-taper or shut-off response. All valves have pressure-seal bonnets and butt-welded ends.

Valve is angle-type, diaphragm-operated in 1,500, 2,500 and 4,500 psi. classes from 1½- through 4-in. sizes. Accessories include handwheels, valve posi-

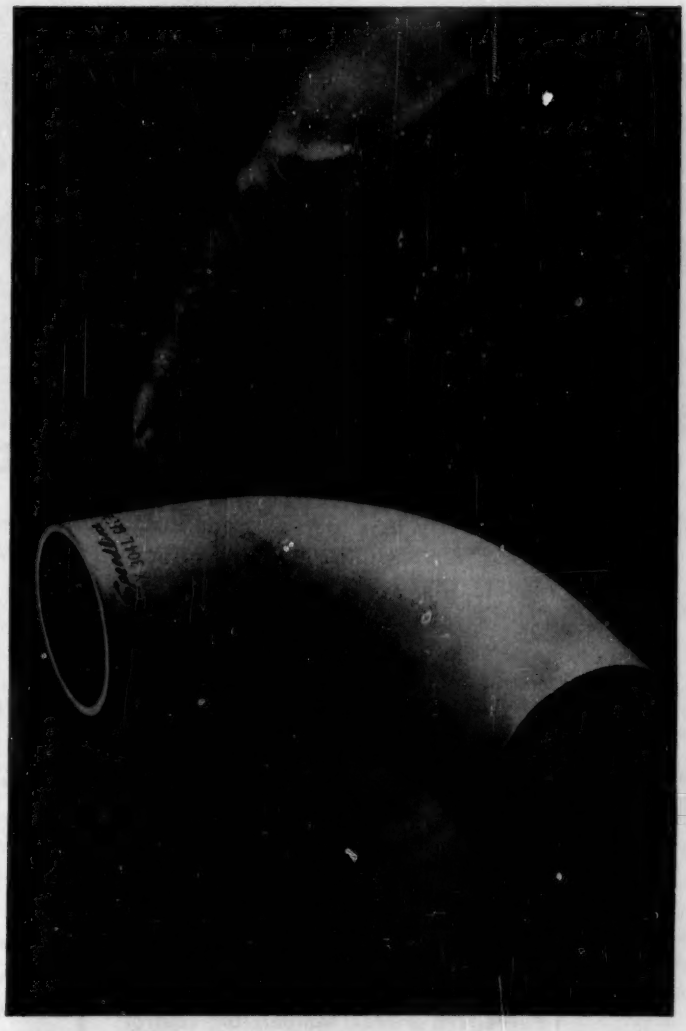
EQUIPMENT NEWS Continues on . . . Page 180

THERE IS A DIFFERENCE IN PIPE FITTINGS

CHECK THESE *Speedline*® FEATURES

THEY INSURE QUALITY... IMPROVE PERFORMANCE

- ✓ **Uniform Wall Thickness at the Bend —in accordance with Specification MSS-SP-43**
- ✓ ***Every* Stainless Steel Fitting Annealed and Pickled**
- ✓ ***Every* Fitting marked with Size, Analysis, Schedule and Production Code**
- ✓ **Certified Chemical Analysis Available on *All* Fittings**
- ✓ ***Complete* Fitting Line — including Eccentric Reducers, Crosses, Reducing Tees, etc.**
- ✓ ***Full Flange Thickness*—to ASA Dimensions**
- ✓ ***Complete* Selection of Metals—Stainless Steel, Aluminum, Hastelloy, Titanium, Zirconium, Carpenter 20**



***Plus* . . . SPEEDLINE STAINLESS STEEL FITTINGS ARE AVAILABLE FROM *STOCK*— *IMMEDIATE DELIVERY* CAN BE MADE BY DISTRIBUTORS THROUGHOUT UNITED STATES AND CANADA**

Speedline are the *original long tangent fittings* with the "extra length" feature—on *every* end of *every* fitting. Speedline design and manufacturing experience is your assurance of process pipe line dependability—and economy. Complete catalog data available on request.

1001

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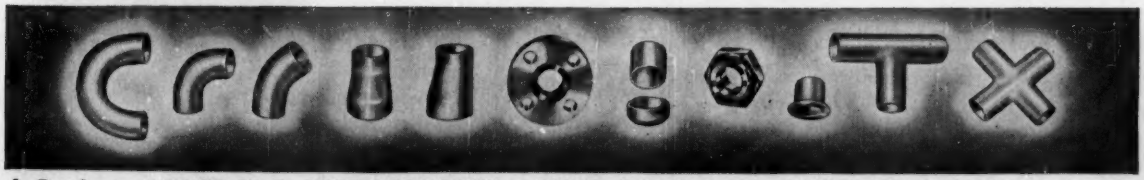
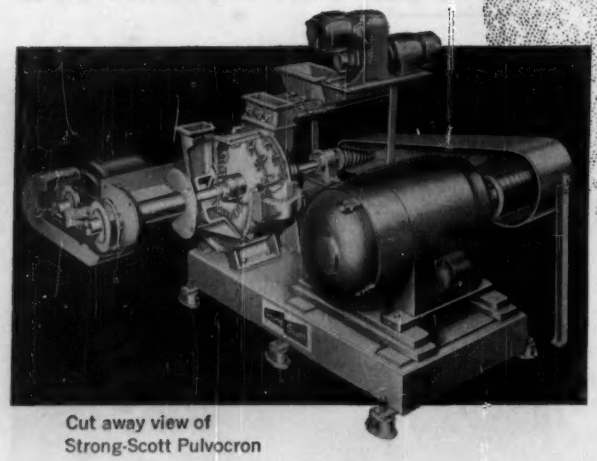
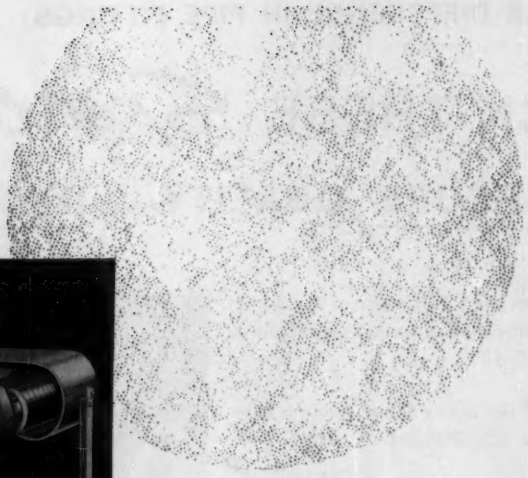
CORROSION-RESISTANT FITTINGS
STAINLESS STEEL • ALUMINUM • SPECIAL ALLOYS



A Product of HORACE T. POTTS COMPANY • 500 E. Erie Avenue • Philadelphia 34, Pennsylvania



Cut away view of
Strong-Scott Pulvocron



Magnified Sample of
SITOSTEROLS
Pulverized to
minus 10 microns

Pulverizing with Selective Particle Size Control!

INCREASE PRODUCTION AND CUT OPERATING COSTS WITH THE NEW PULVOCRON

Because this unit is so versatile, it can pulverize hard or soft materials and can operate in the extreme fineness range (95 to 99% finer than 5 to 10 microns) or it can operate in the coarse particle size range (50 mesh and thereabouts).

The Pulvocron is now being used to solve many size reduction problems in the chemical, food and related process industries. Available in 20 and 38-inch grinding chambers and constructed of carbon or stainless steel.

SPECIAL FEATURES

- **Pulverized product particle size control**
- **Pulverized product temperature control**
- **Installation versatility**
- **Accessibility for inspection**
- **Sturdy construction for years of service**

THE PULVOCRON IS AN ADVANCED IMPACT AND AIR ATTRITION PULVERIZER COMBINED WITH INTERNAL PARTICLE SIZE CLASSIFIER.

TYPICAL INSTALLATIONS USING 20″ PULVOCRON

Product	Soya Sitosterols
Feed Material .	40 Mesh (Approx.)
Pulverized . . .	99.99% minus 10 microns
Capacity. . . .	500 lbs. per hr.

Product	Urea Formaldehyde
Feed Material .	¼ to ⅜″ Diameter
Pulverized . . .	99% minus 80 Mesh
Capacity. . . .	1600 lbs. per hr.

Consult Strong-Scott with your pulverizing problems

The **Strong Scott** Mfg. Co.

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EQUIPMENT DESIGNED FOR BETTER PROCESSING

SWIVEL JOINTS..

modern joints you can

WELD

into the line!

Now you can say..

goodbye to leaky threads C-E joints welded into loading arms eliminate excessive maintenance costs caused by dripping caustic fluids.

goodbye to costly flanges C-E weldable joints eliminate need for flanged connections when fabricating loading arms.

goodbye to higher installation costs C-E weldable joints are easier and faster to install, lower priced and stronger, too.

goodbye to time-consuming packing replacement C-E weldable joints can be repacked when necessary without removal from loading arms.

Continental-Emsco's patented design permits bearings to remain in place *even during* packing replacement or adjustment. Simply loosen set screws and turn body. Joints break like a union, exposing *only* the packing.. bearings are *never* disturbed. Wide spacing of high capacity bearings.. another exclusive C-E feature.. permits greater foot-pound loading on the joint. Additional features include on-location replacement of worn parts.. elimination of split bearing races for added strength.. reversible races on most joints for double service life.

Write today for our new catalog on C-E's modern line of swivel joints.

C-E joints are manufactured for practically all petrochemical and chemical services. Sizes are available from $\frac{3}{8}$" to 12" diameter in steel.. from 2" to 12" diameter in aluminum. Joints are also available in threaded or flanged styles for replacement in existing systems.

SJ002

CONTINENTAL-EMSCO COMPANY

A Division of The Youngstown Sheet and Tube Company

Industrial Products Division
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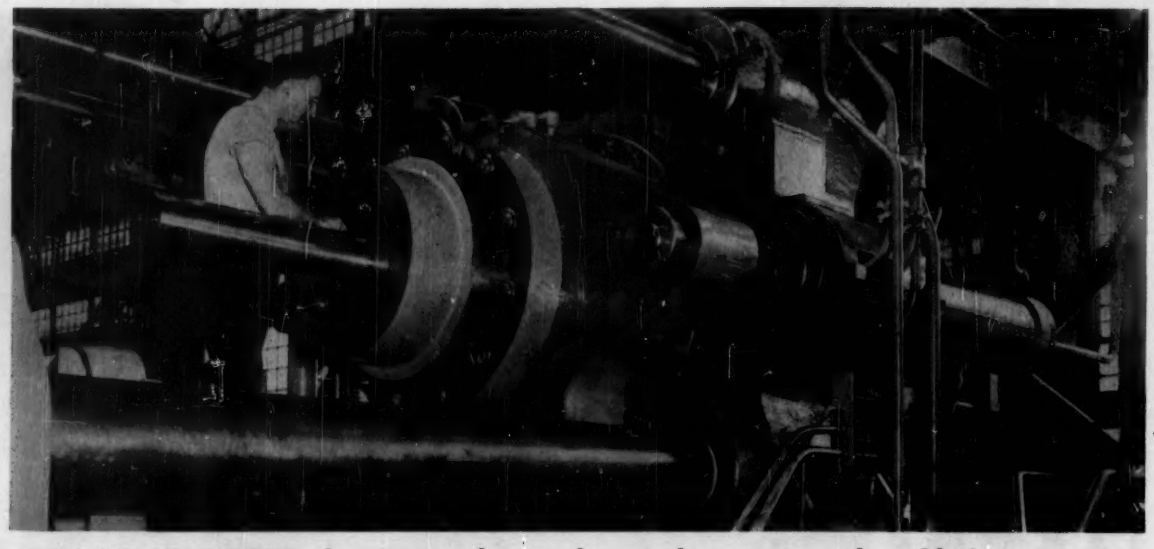
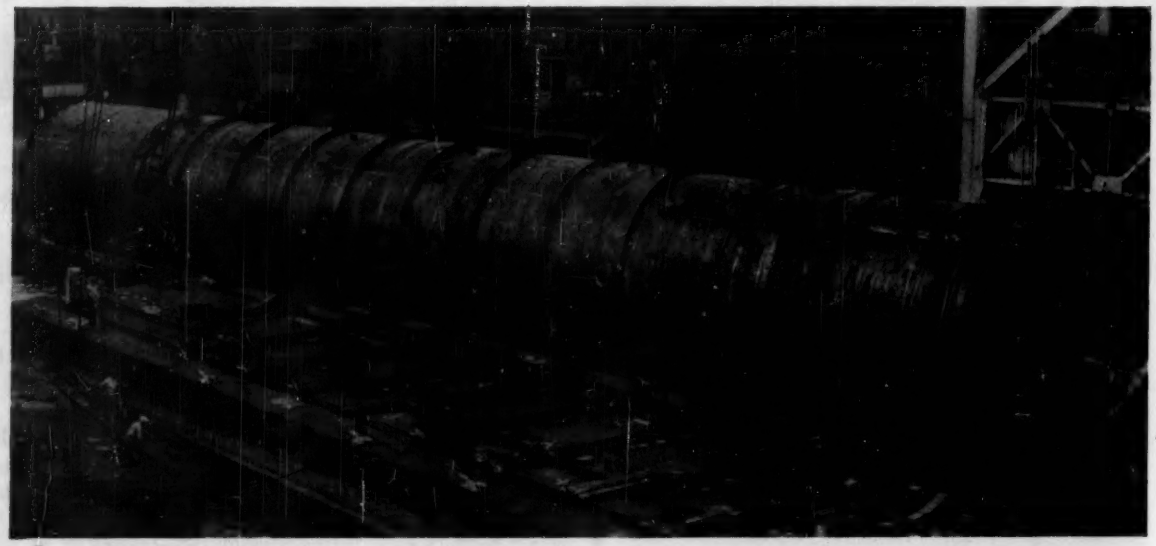


SUN SHIP has what it takes to build . . . . .



for INDUSTRY

We're old hands at building complete machines and special equipment for use in a wide range of industries. For 44 years our large and amply equipped shops have produced items ranging from small tanks to huge fractionating towers, pressure vessels, stills, plate work and special-purpose machinery for the chemical, petroleum and other industries.

Pictured here are a hydraulic press, which was shipped by rail, and a fractionating tower ready for loading on a barge for shipment by water to an oil refinery. They are just two examples of the equipment Sun Ship contributes to many fields, also examples of our shipping facilities.

Because we have all the facilities, we build all equipment right in our own plant, without subletting. Our convenient location on the Delaware River, with direct access by rail and water to all points, assures speedy delivery.

Let Sun Ship solve your machine or equipment problem. Phone or write our Sales Engineering Department.

Sun

SHIPBUILDING & DRY DOCK COMPANY

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Now you can ship caustic soda in 50- or 100-lb. bags . . .

Bemis Caustic Soda Bags

Bemis Caustic Soda Bags, approved for both rail and truck shipment in 50- and 100-lb. sizes, dramatically change the packaging picture for caustic soda. These rugged bags give you economies you can't afford to pass up . . . plus other important benefits. Expensive steel drums are made obsolete. Call your Bemis packaging specialist today for complete details. Or, write, wire or phone us.

EIGHT BIG BENEFITS ■ **Lower Cost**—Considerably below what you now pay for steel drums. ■ **Storage Economy**—A ton of caustic soda packed in Bemis Bags takes 50 per cent less storage or shipping space than a ton packed in drums. ■ **Empty Container Storage Economy**—400 empty Bemis Bags take a fraction of the space occupied by 200 drums. ■ **Lower Freight Costs**—The bags to carry one ton of caustic soda weigh 100 pounds less than the drums needed for the same job . . . a 75 per cent saving in package weight, a 5 per cent over-all tare weight saving. ■ **Labor Savings**—One truck can be loaded in 20 minutes with palletized bags; same truck takes 1½ hours to load with drums, using three men in each case. ■ **Better Handling**—Bemis Caustic Soda Bags are easy and safe to handle and stack. Nonslip surface permits safe palletizing. ■ **Easier, Cheaper Disposal**—Just burn or bury the used bags; you know the problems of disposing of drums. ■ **Strength**—Bemis Laminated-Textile Bags—Caustic Soda Bags are one type—have been called the toughest shipping sacks made. Actual shipments by one manufacturer have proved they carry caustic soda as safely as drums.

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Where flexible packaging ideas are born

Flexible Process Makes Silicone Rubber

General Electric's plant is the setting for this first published look at how a versatile silicone rubber operation yields a broad, full line of the silicon-hydrocarbon elastomers.

Evidence that the silicone rubber business continues to thrive was supplied this spring by General Electric Co., when the firm announced that it is undertaking a major expansion at its Waterford, N. Y., silicones plant.

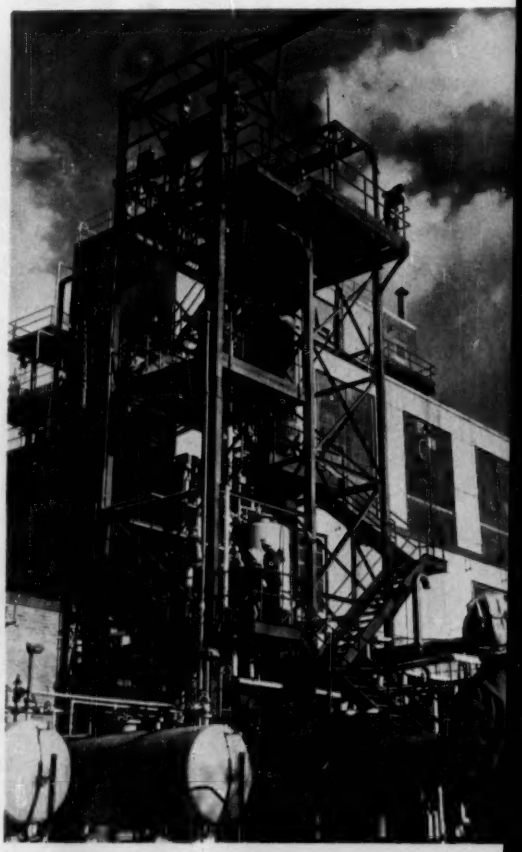
GE is one of the "big three"—with Dow Corning and Union Carbide—in the silicone rubber field. The Waterford plant puts out a diversified line of some 50 fully commercial grades, plus numerous others in developmental stages. In showing GE's rubber operation on these pages, *Chemical Engineering* presents the first published look at how silicone elastomers are made.

Silicone rubbers first made their appearance during World War II, when they were used in making Navy searchlights and in other military applications. Production for nonmilitary uses started soon after the war was over, and the Waterford plant has been manufacturing the synthetic elastomers commercially since 1948.

Rubber dominates GE's Waterford output, which also includes silicone fluids and resins. Not only do the elastomers represent the greatest sales volume, but they also require particular attention in their manufacture. GE prepares and purifies its raw-material siloxane stocks for the elastomers with great care, and maintains tight quality checks throughout the entire process, particularly during polymerization and stabilization of the various silicone gums which constitute the bases of all the rubber products.

►Plus-Marks—Several virtues help explain the popularity of the elastic silicon-hydrocarbon compounds. They maintain performance characteristics over a wide temperature range (—100 to 500 F. is typical). They show excellent release from sticking, and are not tacky even at high temperatures. Another virtue is their inertness to numerous chemicals, lubricants and other oils. And they

ATMOSPHERIC BATCH STILL in foreground purifies siloxane feedstock for polymerization.



Unfold Flowsheet

exhibit unusual surface behavior, including arc and ozone resistance, and burn to a non-conducting ash.

These and other properties have gained for the rubbers a long list of applications, particularly in such areas as electrical insulation, gasketing and ductwork, and potting and encapsulation. GE's forthcoming expansion is based on steady, widespread market increase rather than on sudden growth in any one customer or application area.

Two specific uses illustrate the elastomers' versatility. A significant amount of silicone rubber can be found in the innards of missiles launched at Cape Canaveral. And they have found use in medicine and surgery—for instance, through intravascular systems made from silicone rubber tubing.

▶ **Building Blocks**—GE starts all of its silicones production with a reaction between silicon and methyl chloride. The reaction yields a gaseous mixture of three products, and one of these, dimethyldichlorosilane, is the basic material for rubber manufacture:

$$Si + CH_3Cl \longrightarrow (CH_3)_2SiCl_2$$

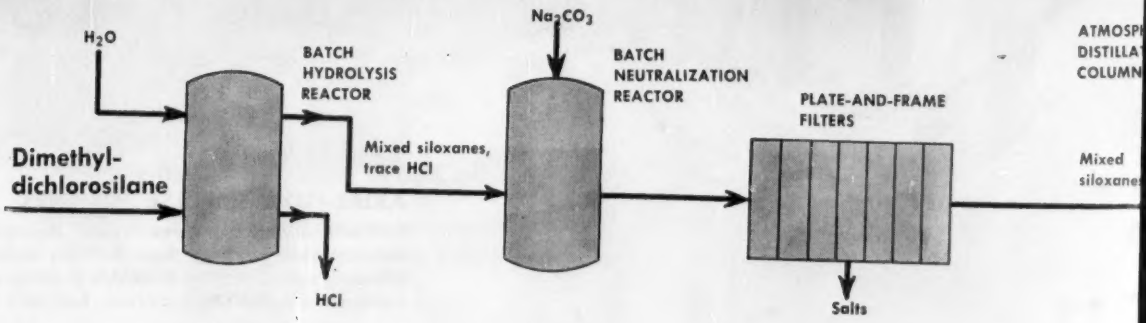
The other products formed are trimethylchlorosilane and methyltrichlorosilane, which are used to make fluids and resins. (See Process Flowsheet, *Chem. Eng.*, Dec. 1957, p. 228.) GE separates the three by condensing and then fractionally distilling the mixture.

▶ **Kickoff for Rubber**—First step in making rubber is to hydrolyze the dimethyldichlorosilane. Hydrolysis product is a mixture of siloxanes—compounds of silicon, oxygen and hydrogen or hydrocarbons—which begin to polymerize, to a limited extent, in the hydrolysis reactor:

$$(CH_3)_2SiCl_2 + H_2O \rightarrow [CH_3\text{–}SiO\text{–}CH_3]_n + HCl$$

POLYMERIZATION VESSEL yields the clear, water-white gum seen draining below. Typical molecular weight is 500,000. Gum goes next to stabilization reactor.

RUBBER MILL (belo blends gum with filler



GE carries out the hydrolysis around 85–125 F. in a glass-lined vessel that holds some 500 gal. Aqueous (HCl) and organic (siloxane) phases are then allowed to settle out in the reactor. The HCl is drawn off; the siloxane mixture is led to a similar reactor where Na_2CO_3 neutralizes remaining trace HCl.

The material next goes to plate-and-frame filters which remove salt produced during neutralization.

The limited polymerization in the hydrolysis reactor produces a linear siloxane molecular structure with some cross-linkages. For best-quality rubber the feed to subsequent full-scale polymerization must be free of these linkages. Hence the fluid is purified at this point in an atmospheric batch still, and material rich in cross-linkages is drawn off as bottoms.

► **Polymerize, Stabilize**—Overhead from the still is condensed, and is then ready to be polymerized to gum. It is fed to a stainless steel vessel along with an undisclosed catalyst which, says GE, may be either acidic or basic. Trimethyl siloxane is also added; it acts as a "chainstopper" to halt polymerization at the desired molecular weight, and the amount used depends on the gum hardness that GE wants for the batch in question. Other siloxanes may be added, too, to contribute specific qualities to the final product.

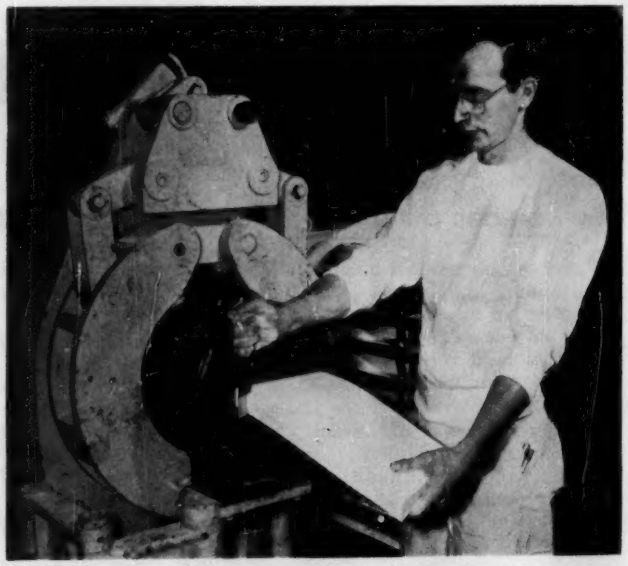
Polymerization takes place under agitation at 210–390 F. The total cycle requires some eight hours.

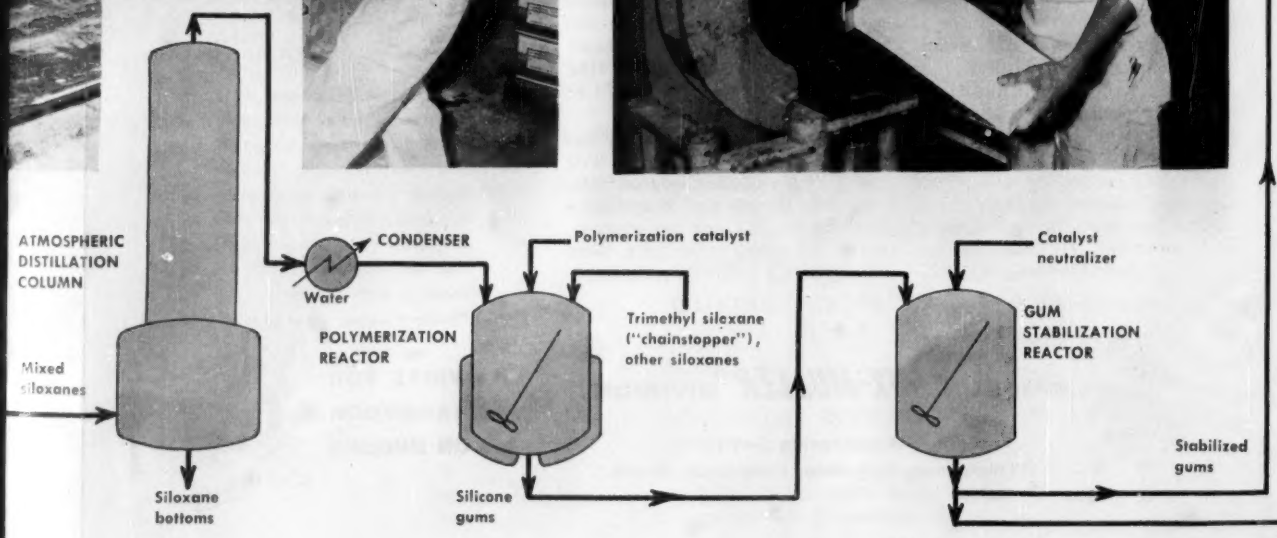
The polymerized gum is then stabilized, at a lower temperature, in a vessel similar to the polymerizer. Agents are added here to neutralize the polymerization catalyst.

► **Batch, Compound, Screen**—The stabilized gum is ready to be compounded with fillers, as well as

L (below), dough mixer or Banbury mixer thoroughly h filler and other additives.

EXTRUDER screens all compounded gum mixtures, including uncured solid grade shown below, to assure a clean final product.





additional silicones (to provide physical or handling properties), coloring agents or catalysts to aid vulcanization at the customer's plant. Some customers prefer to do their own compounding, and GE accordingly may take gum from the stabilization vessel and drum it directly.

Gum which GE itself compounds is taken to a batching room, where the additives and gum are weighed out. Additives always include a filler, which may be a reinforcer (such as fumed silicas) or a nonreinforcing filler to act as extender.

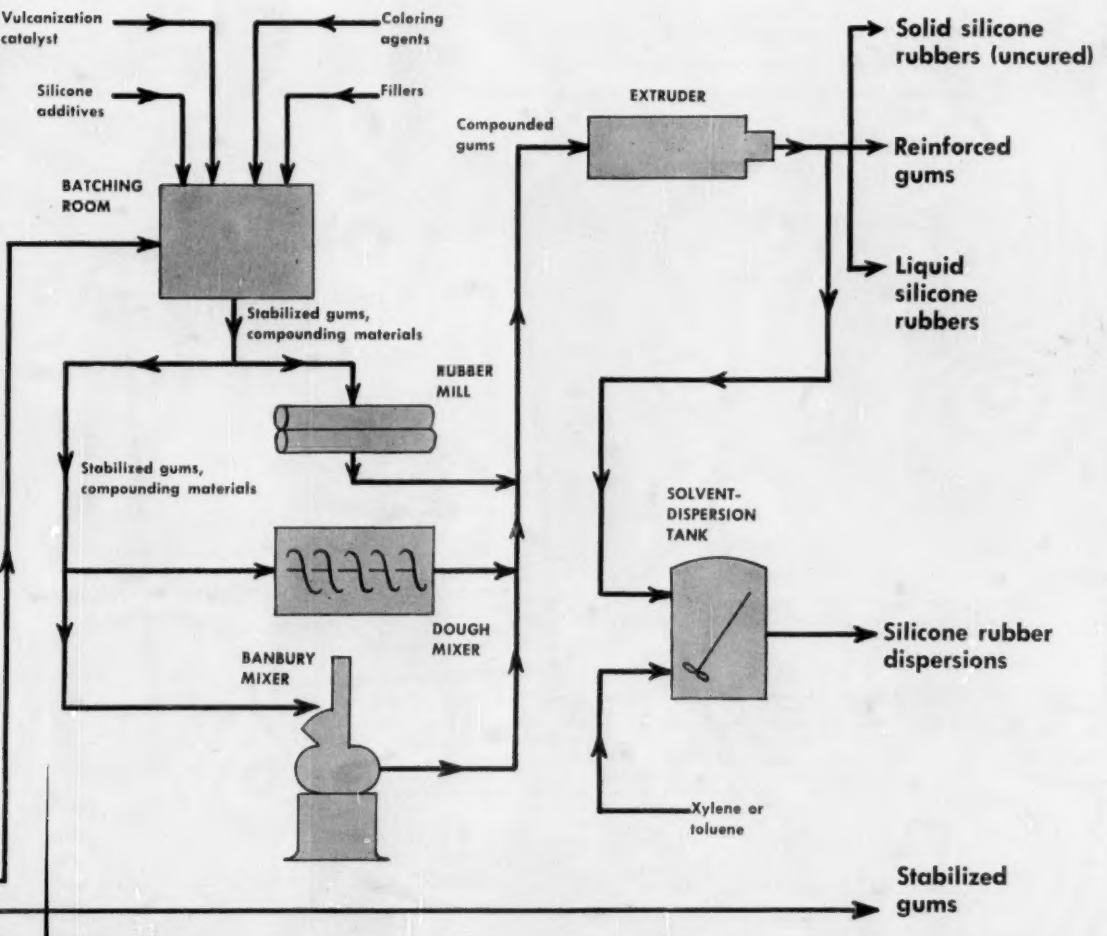
The gum and other weighed ingredients are then wheeled to a rubber mill, a dough mixer or a Banbury mixer for compounding. GE generally uses the dough mixer for large batches, but finds that the Banbury mixer works best for batches highly loaded with filler.

The compounded gum leaving the mill or mixer goes to an extruder, where it is forced through a screen to remove any traces of dirt introduced with the filler.

►**Four Varieties**—GE sets its polymerization, batching and compounding conditions so as to produce a solid grade, a reinforced gum, a liquid grade or a dispersion in solvent, depending on the customer's fabrication technique and end use for the material.

If the material is to be sold as a solid, an appropriately shaped head or die is placed at the extruder exit. If it is to be sold as a reinforced gum, a liquid or a dispersion, it leaves the extruder through a large, nonrestrictive head.

Reinforced gums are packaged in plastic bags; liquid grades are drummed. Dispersion grades are finished by feeding extruder product to a propeller-agitated tank, where it is dispersed in toluene or xylene. This mixture then passes through a line filter and on to drumming.



Only
TURBULAIRE-DOYLE
SCRUBBERS

GIVE YOU JET-ACTION GAS-CLEANING
WITH NO MOVING PARTS!

The Turbulaire-Doyle Scrubber is unique in its high collection efficiencies and low maintenance requirements because it incorporates a jet-action design that assures a far more thorough scrubbing action—yet requires no complex mechanical systems that boost maintenance and repair costs.

THE JET-CONE MAKES THE DIFFERENCE!

This Jet-Cone in the throat of each Turbulaire-Doyle inlet tube causes a sharp increase in the velocity of the incoming gases—the velocity reaching maximum at the point where the dirt-laden gases impinge upon the scrubbing liquid.

RESULT: ***unusually deep penetration of gases into the scrubbing fluid for more complete cleansing of all suspended particles—even those in the fume range.***

Yet there are no moving parts—nothing to require frequent repair or replacement!

ILLUSTRATED ABOVE: Two-stage rubber-covered units remove dust and fume from gases at wet process phosphoric acid plant. Capacity: 64,000 CFM.

Compare
TURBULAIRE-DOYLE ADVANTAGES

- **HIGH COLLECTION EFFICIENCIES** generally in the 97% to 99% range.
- **FINE PARTICLE COLLECTION** even fume-range particles.
- **LOW LIQUID-TO-GAS RATIO** only 1 to 5 GPM/1000 CFM.
- **NEGLIGIBLE MAINTENANCE** no moving parts to wear or corrode—no "plugging" problems.
- **NO CORROSION PROBLEMS** simple design permits wide choice of corrosion-resisting materials.

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MIX-MULLER®

means CONTROLLED DISPERSION for dry solid materials

Model LF Mix-Muller
Manufactured to same standards as high production Mix-Mullers. Ideal for controlled mulling of small production batches or for laboratory or pilot plant.

Now you can put it to work for less than $1600

If you're coating a fine dry material; blending liquids into a dry powder . . . or dispersing a small amount of one material into another—you need *more* than a simple stirring, tumbling or agitator action can *give*.

You need *controlled dispersion*. You get it with Mix-Muller . . . a unique three-way kneading, smearing, spatulate action that actually coats one material with another. It's an intensive but thoroughly controlled *mulling* action which slashes waste by eliminating the need for reprocessing and remixing. By making the *most* of prepared ingredients, Mix-Muller can turn problem mixing operations into a new source for *profit*.

That's a big order in these days of expensive raw materials. But it's exactly why more and more processors, caught between demands for optimum quality, soaring costs, and outdated mixing facilities, are turning to Mix-Muller.

Can you afford to settle for less than *controlled dispersion*? The new LF Mix-Muller, quoted here, can make it easy and inexpensive for you to *find out for yourself*, under your own conditions. Why not write for a formal proposal?

See our advertisement: CHEM. ENGINEERING CATALOG

SIMPSON MIX-MULLER® DIVISION
National Engineering Company
636 Machinery Hall Bldg. • Chicago, Illinois

P 860

PRICE . . . $1,549 FOB Chicago*

¼ to ¾ cu. ft. capacity. Comes equipped with 1 HP motor and starter, V-belt drive, removable dust hood, crib and muller scrapers, liquid additions funnel, integral base for bench mounting and 4 pipe legs for floor mount. No foundations necessary. Has machined crib and mullers; discharge is automatic, by bottom door.

**Same in stainless steel $2,850*

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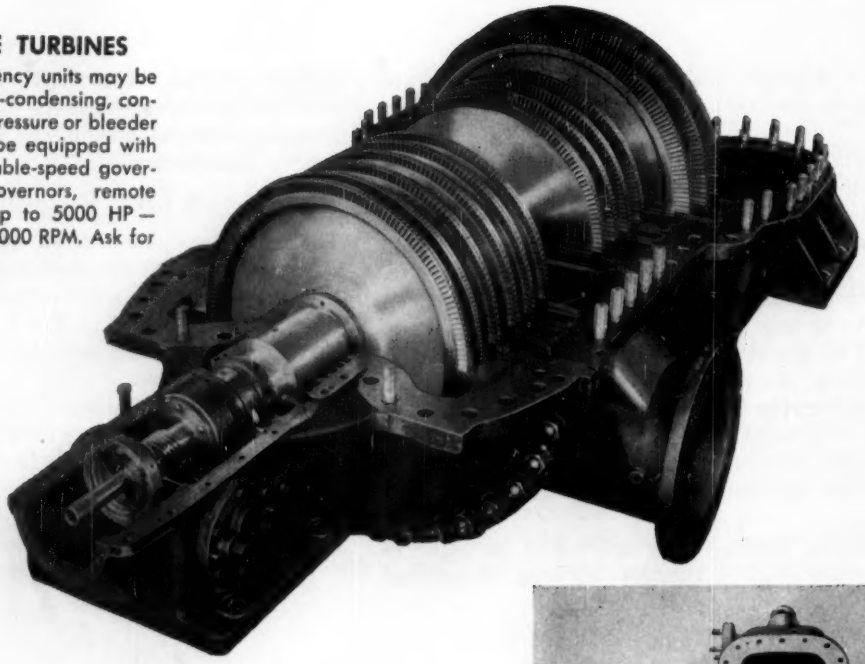
MULTI-STAGE TURBINES

These high-efficiency units may be designed for non-condensing, condensing, mixed pressure or bleeder operation. Can be equipped with constant or variable-speed governors, special governors, remote controls. Sizes up to 5000 HP — Speeds up to 10,000 RPM. Ask for Bulletin S-146.



There's a **Terry turbine** for every mechanical-drive requirement

The designs for Terry turbines are based on more than 50 years of successful experience in the manufacture of turbine drives *exclusively*. This specialization has resulted in Terry becoming one of *the leading producers* of mechanical-drive turbines in sizes up to 5,000 horsepower.

There are three basic reasons why Terry has been able to maintain this position of leadership: (1) a thorough knowledge of the requirements of mechanical-drive turbines, (2) a willingness to build "a little something extra" into each machine to assure trouble-free operation, and (3) an acknowledgement of the company's responsibility to stand behind the performance of every turbine sold.

These are also the reasons why you should consider a Terry turbine for your next mechanical drive. In the meantime, send for bulletins describing any of the types of machines illustrated.

THE TERRY STEAM TURBINE COMPANY
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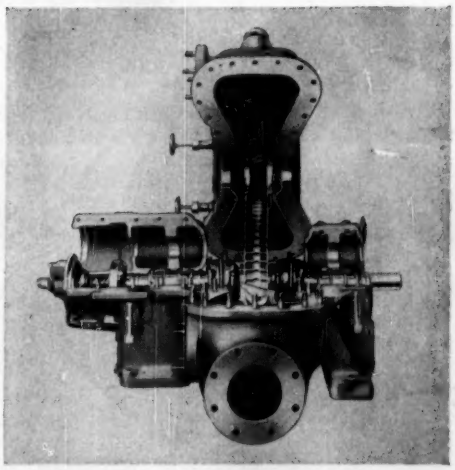

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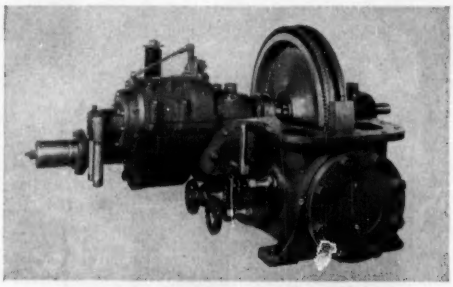

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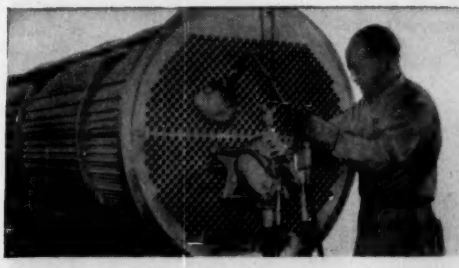
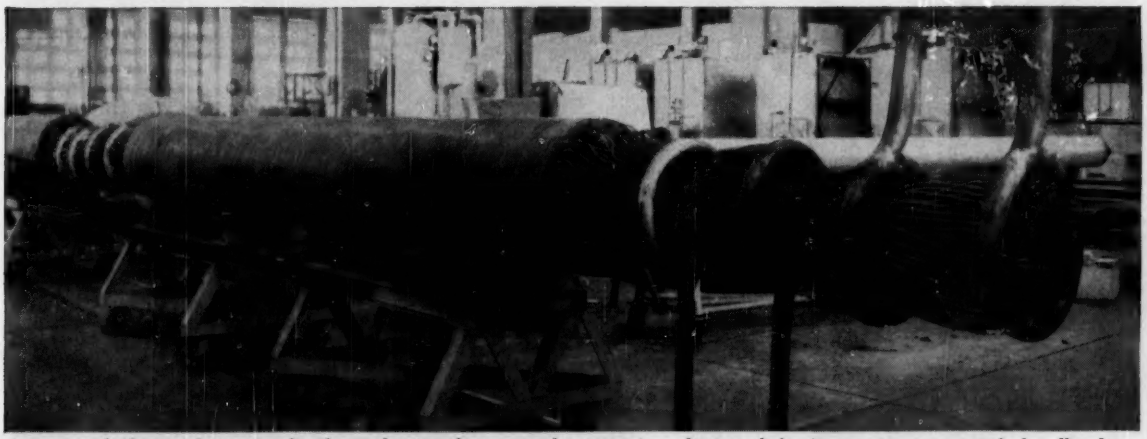


CONDENSER AND HEAT EXCHANGER CLINIC

Edited by Arthur W. Tracy, Metallurgical Engineer
The American Brass Company, Waterbury, Conn.

Cryogenic heat exchanger uses 16 miles of copper tube



A copper-tube heat exchanger used in the production of oxygen and nitrogen in a large low-temperature processing plant made by AIR PRODUCTS, INC., Allentown, Pa. The ⅜" tubes are wound tightly and built up layer by layer for greatest possible surface contact – and maximum heat transfer between the oxygen and air tube systems (see diagram below). AIR PRODUCTS winds bundles from long lengths of Anaconda tube. A total of 85,200 feet is used in this exchanger, for a total weight of 14,500 pounds. The "button-hook" manifolds for the tube systems are of Red Brass pipe, with extra-heavy or double-extra-heavy wall.

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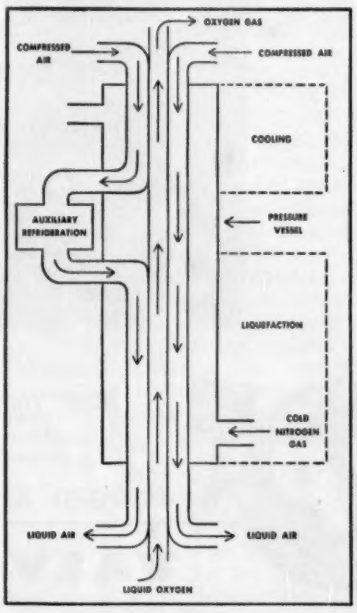

Schematic diagram of heat exchanger used in the production of oxygen and nitrogen. Incoming air under pressure passes through a set of coils in the exchanger and is cooled by counter current heat exchange by cold outgoing oxygen and nitrogen. Oxygen from the distillation column enters the heat exchanger as a liquid under pressure and, in removing heat from the air, vaporizes to a gaseous form and leaves the heat exchanger at near entering air temperature. Part way through the heat exchanger, the air is removed from the heat exchanger and sent through a Freon cooling system for auxiliary refrigeration and then returned to the exchanger for final cooling.

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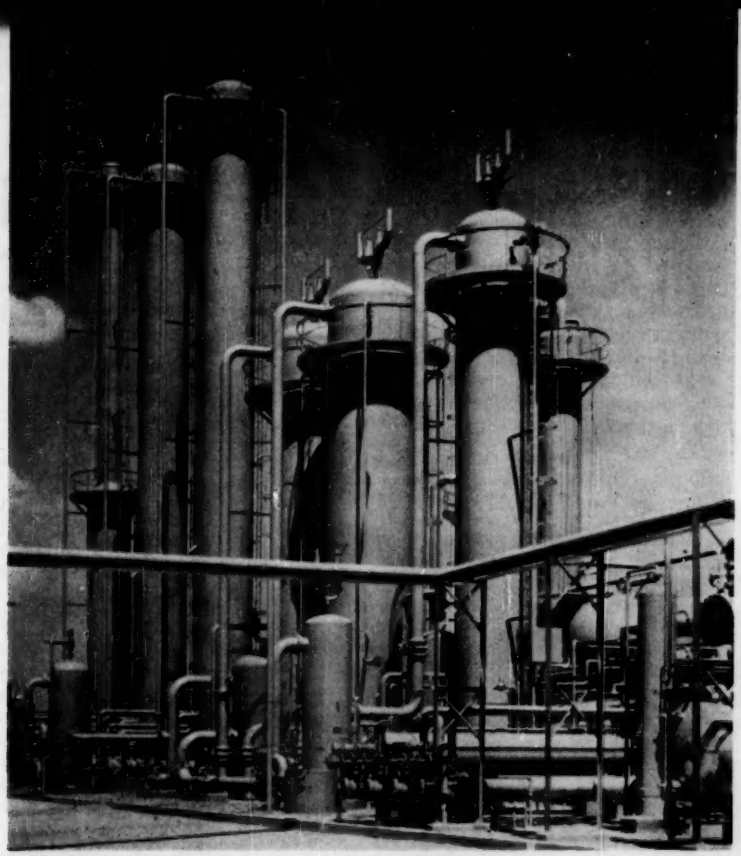


A realistic explanation of the many problems in absorption equipment can lead to more effective and economic design by understanding modern concepts of . . .

Absorption With Chemical Reaction

AARON J. TELLER, University of Florida and Colonial Iron Works

Absorption is a type of mass transfer that applies to the recovery of solute gases in the presence of noncondensables. The absorption process occurs in a wide range of uses from recovery and recycle of stream components, to tail-gas recovery in air pollution and to vacuum degasification of water.

In recognition of the importance of absorption, it was one of the first operations studied intensively in the field of chemical engineering. Although the first theories presented were usable as approximative design tools for certain types of systems, the results of this success have become dangerous.

Application of these early models has been made to systems whose behavior is only slightly related to the original concepts of the mechanism of mass transfer. As a result, their use has often resulted in "anomalous and peculiar" behavior of the system. Actually, the reverse is true. It is the use of nonapplicable models of behavior that is anomalous and peculiar.

An example of the anomalous results of misapplication is the use of the two-film physical absorption model to absorption accompanied by chemical reaction. The two-film theory tells us that the over-all coefficient of mass transfer is related to the individual coefficients by the relation:

$$K_G a = \frac{1}{\frac{1}{k_G a} + \frac{m}{k_L a}} \qquad (1)$$

where m is the slope of the equilibrium line relating the gas phase and liquid phase concentrations.

In highly-soluble gas systems, the slope m approaches zero. Therefore,

$$K_G a = \frac{1}{\frac{1}{k_G a} + \frac{0}{k_L a}} = k_G a$$

Hence, we have a gas phase controlling system where the liquid phase offers no resistance to mass transfer.

In the case of absorption accompanied by chemical reaction, the solvent is generally chosen such that it ties up the solute gas chemically so that no equilibrium partial pressure exists for the gas when dissolved. Via traditional thinking, m again approaches zero and from two-film theory the over-all coefficient is equal to the gas phase coefficient. This analysis leads us to believe that the liquid phase resist-

Absorption Systems—Table I

By Physical Transfer

Solute Gas	Solvent
O_2	H_2O
N_2	H_2O
Condensation	
Evaporation	

With Chemical Reaction

Solute Gas	Reagent
CO_2	Carbonates
CO_2	Hydroxides
CO_2	Ethanolamines
CO	Cuprous amine complexes
CO	$CU(NH_3)Cl$
NH_3	H_2O
NH_3	H_2SO_4
SO_2	$Ca(OH)_2$
SO_2	Ozone-H_2O
SO_2	$HCrO_4$
SO_2	KOH
Cl_2	H_2O
Cl_2	$FeCl_2$
HCl	H_2O
H_2S	Ethanolamines
H_2S	$Fe(OH)_2$
SO_3	H_2SO_4
C_2H_4	KOH
C_2H_4	Triakyl phosphates
Olefins	Cuprous ammonium complexes
NO	$FeSO_4$
NO	$Ca(OH)_2$
NO	H_2SO_4
NO_2	H_2O

ance is negligible if we use the same pattern of thinking that we use in physical absorption. In the majority of cases, we would be wrong.

We do have new tools of analysis. They don't force the old ones into obsolescence. It is just that we have to apply the model that fits the situation and not restrict our interpretation to a single one.

The necessity for using all the tools is indicated by the classification in Table I of the types of problems we encounter in practice. Although we use the physical absorption two-film theory extensively in industry, most of our problems are those where chemical reaction occurs.

Therefore, it seems reasonable that the development of concepts beyond our initial breakthrough be analyzed with respect to their application to interpretation of the behavior of our systems. The newer analyses are concerned primarily with the liquid phase behavior. It is in the liquid phase that the slowest or limiting transfer occurs and the behavior model of the gas phase has been substantiated by repeated tests.

What Is Two-Film Theory?

Oldest and most widely used model for interpretation of column behavior is the Whitman[28] two-film theory. This model relies on a series of assumptions for its utilization.

1. Steady state conditions exist in both phases.
2. Rate of transfer is proportional to the concentration gradient.
3. Equilibrium exists between liquid and vapor at the interface with no interfacial resistance to flow.
4. Hold-up at the interface is zero.

On the basis of these assumptions:

$$N_A = K_G a V(p^* - p_G) = K_L a V(C_L - c^*) \quad (2)$$

where

$$K_G a = \frac{K_L a}{m} = \frac{1}{\frac{1}{k_G a} + \frac{m}{k_L a}}$$

$$H_{OG} = H_G = \frac{mG_m(1-x)f}{L_m(1-y)f} H_L \quad (3)$$

These equations indicate an additivity of resistances similar to that used in heat transfer via conduction.

Examine Penetration Theory

Subsequent to the work of Whitman, there have emerged the Higbie[31] penetration theory and the Danckwerts[8] surface renewal modification of the penetration theory. The Higbie theory indicates that the transfer into a laminar liquid phase occurs via an unsteady state mechanism such that the rate of absorption decreases with time of exposure even with a constant concentration gradient. The Danckwerts theory indicates that eddies in the liquid layer tend to increase the rate of absorption to a degree greater than the penetration theory implies.

The concept of penetration into a liquid layer has been found applicable to wetted-wall columns and packed columns where the liquid is in the laminar regime.

Via the two-film theory that effectively lumps all the resistances to mass transfer into an equivalent conduction film, mass transfer rate becomes:

$$k_L \propto D_L \quad (4)$$

Via the penetration theory and on the basis of the two-film equivalent, the relationship of the mass transfer rate to diffusivity is:

$$k_L = 2(D/\pi t_e)^{1/2} \quad (5)$$

where t_e is the time of penetration.

Via the surface renewal modification:

$$k_L \propto (Ds)^{1/2} \quad (6)$$

where s is the surface renewal rate.

Thus, if a given statistical average penetration time exists in a packed column under constant flow conditions, the film coefficients in physical absorption of one system may be obtained from the behavior of a known system via the relationship:

$$k_{L1} = k_{L2}(D_{L1}/D_{L2})^{1/2} \quad (7)$$

for the penetration or surface renewal theories, and

$$\frac{k_{L1}}{k_{L2}} \propto \frac{D_{L1}}{D_{L2}} \quad (8)$$

for the two-film theory.

Actual behavior in physical absorption in the liquid film in packed columns obtained in the study by Sherwood and Holloway[16] indicates that

$$k_L \propto (D_L)^{1/2} \quad (9)$$

Consider Chemical Reactions

If the absorption problems encountered in industry were essentially those of physical absorption, we then would have adequate, albeit incomplete, tools for an effective comparative basis of design. However, most of our absorption problems are those accompanied by chemical reaction. This situation has resulted from a desire by chemical engineers to obtain gas-phase controlling systems. The reason is obvious since if a physical absorption process exists, the rate of transfer in the gas phase is generally 10 to 100 times as great as that in the liquid phase.

Thus, if a system using a solvent providing high solubility for the solute gas exists or where the equilibrium partial pressure is low,

the resistance of the liquid phase to transfer is minimized. In this case, the major resistance occurs in the gas phase where transfer rates are more rapid than in the liquid phase. This situation can be illustrated by use of the two-film analog:

$$K_G a = \frac{1}{\frac{1}{k_G a} + \frac{m}{k_L a}}$$

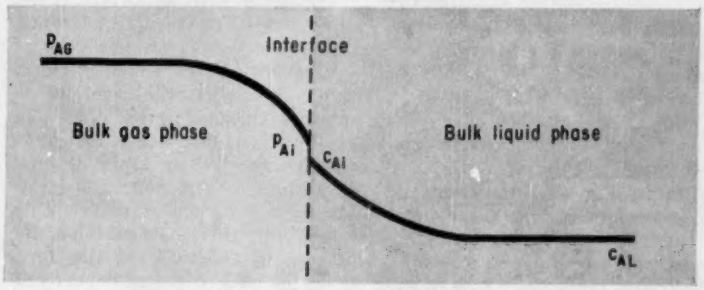
If m is small or approaching zero, then $K_G a = k_G a$; whereas when m is large (low solubility) $K_G a$ approaches k_L/m. Since k_G is much larger than k_L, the process will be more rapid in the gas-phase controlling system and the equipment size will be smaller.

In our attempt to obtain systems where m is small, we have generally utilized processes which incorporate a rapid irreversible reaction between the solute gas and a chemical reagent dissolved in the liquid phase or with the liquid phase as the reactant. In fact most of our commercial systems for absorption employ this device to obtain a gas-phase controlling behavior.

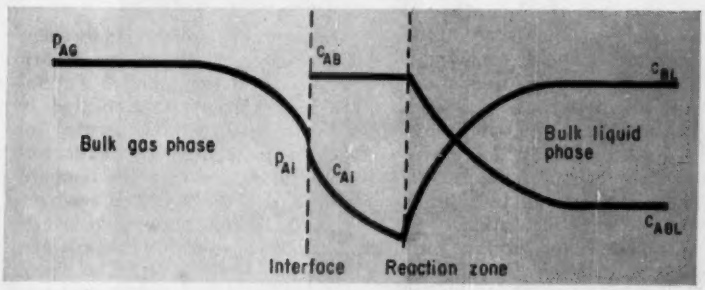
Although an irreversible chemical reaction in the liquid phase results in an effectively zero equilibrium partial pressure of the solute gas over a wide range of concentrations, the implication of the two-film theory equation that the absorption becomes gas phase controlling is not true.

The relative resistances of the gas and liquid phases in the diffusion mechanism in absorption accompanied by chemical reaction are now not only functions of the diffusivities of the solute gas in the vapor and liquid phases, solubility and penetration time; but also on the concentration of unreacted reagent, rate of diffusion of the reagent through the solvent liquid and the rate of reaction.

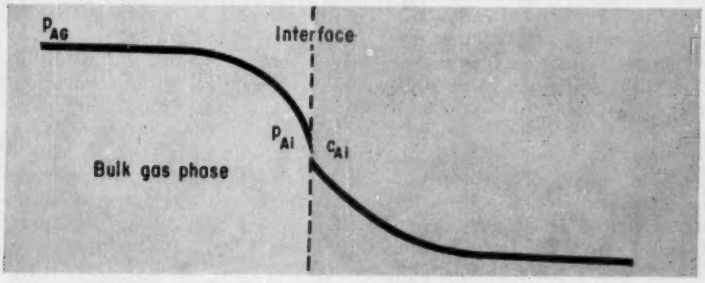
How Concentration Varies in Physical Absorption—Fig. 1



Absorption With Fast Chemical Reaction—Fig. 2



Absorption With Slow Chemical Reaction—Fig. 3



Compare the Theories

Differences between the physical process, absorption accompanied by a rapid chemical reaction and one accompanied by a slow reaction are indicated in Figs. 1, 2 and 3.

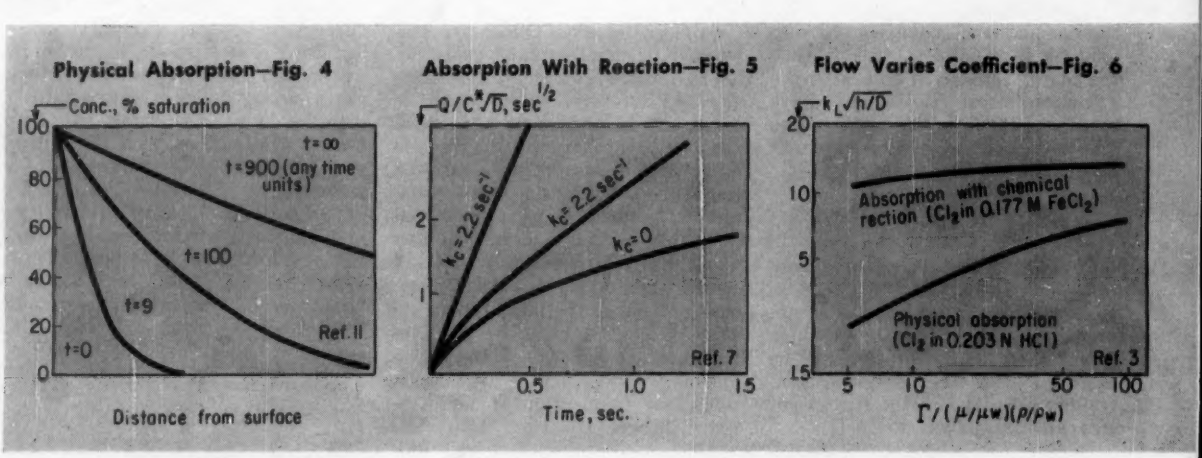
In physical absorption (Fig. 1) the mass transfer rate is dependent on the concentration gradients and diffusivities of the solute gas in both phases. With the addition of a rapid chemical reaction (Fig. 2) the distance through which the solute gas must diffuse in the liquid phase is generally decreased because upon meeting with reagent B, reaction occurs. Hence the necessity for further diffusion no longer exists. Thus the over-all mass transfer rate is increased. The distance through which the solute gas must diffuse depends upon the availability of the reagent which is a function of its concentration and diffusion rate.

For a slow chemical reaction (Fig. 3) the distance through which solute gas A must traverse is only slightly affected and the process approaches that of physical absorption. No significant advantage over physical absorption processes is gained.

Thus, as a function of the reaction rate and availability of reagent to the solute gas, the absorption accompanied by chemical reaction may approach that of the gas-phase controlling system where the reaction occurs in proximity to the interface as in Fig. 2; or may approach that of a liquid phase controlling system as in Fig. 3; or where the reaction occurs at a large distance from the interface as in Fig. 2.

Select Adequate Reagents

Thus, via adequate choice of the reagent a significant increase in rate of absorption can be achieved,



reducing the size of equipment involved and the quantity of the solvent streams to be recirculated.

Additional advantages can accrue by proper selection of the reagent system as follows:

1. Increased capacity for the gas per unit weight of solvent.
2. Increased utilization of stagnant zones in packed towers resulting in an over-all improvement in performance of the packing.
3. Decreased dependence on liquid rate for effective mass transfer.
4. Recovery of pure solute gas.

Increase in solvent capacity for the solute gas is a function of the concentration and reactivity of the reagent. However, an increase in concentration can result in negative effects such as increase in viscosity that will slow up the over-all process. Thus, variation in concentration must be approached with caution.

Increased utilization of stagnant liquid zones for mass transfer is obtainable when chemical reaction accompanies absorption. The absorption mechanism proceeds via penetration into the liquid phase when the liquid is in the laminar or stagnant condition. Thus in physical absorption the concentration of the solute gas in the liquid phase at any point will increase with time of exposure as shown in Fig. 4.

The concentration gradient decreases with time and the effective mass transfer coefficient based on the gross gradient k_L which is proportional to $(1/t_e)^{1/2}$, also decreases with time.

Where chemical reaction accompanies the absorption the reagent removes the solute gas via reaction. This minimizes the decrease in gradient with time and results in an increased rate of absorption in the stagnant zones. The effect was demonstrated by Danckwerts[7] and is indicated in Fig. 5.

Note in Fig. 5 that where no reaction occurs ($k_c = 0$), the quantity absorbed reaches an asymptote in the region of 1.5 sec. exposure. Beyond this region, the rate of absorption approaches zero. With a chemical reaction occurring at a rapid rate ($k = 22$ sec.$^{-1}$) with sufficient reagent, the quantity absorbed is almost unaffected by time and the rate is almost constant.

Thus, those zones in a packed column where surface renewal is not rapid will contribute to the over-all mass transfer more effectively when chemical reaction accompanies absorption than in the case of physical absorption.

The effect of chemical reaction in reducing the dependence of absorption rate on the penetration mechanism is reflected in a lower effect of liquid rate on the mass transfer rate in a physical absorption process. An increase in liquid rate in a packed or wetted-wall column results in an increased surface regeneration via rippling and increase in the mobility of the liquid in through interstices. With a lower dependence on surface regeneration to decrease the effect of penetration when chemical reaction occurs, the change in mass transfer coefficient with liquid rate is minimized. Baddour and others[8] showed this phenomenon in a wetted-wall column using the system Cl_2-air-$FeCl_2$ (H_2O) which is given in Fig. 6.

Recovery of pure solute gas may be achieved when the chemical reaction is thermally reversible. The use of absorption accompanied by chemical reaction generally depends on such a phenomenon in order to achieve economic feasibility. With a thermally reversible reaction, the process is generally of the form indicated in Fig. 7 and depends on the reaction:

$$A + B \underset{T_2}{\overset{T_1}{\rightleftharpoons}} AB$$

Absorption accompanied by chemical reaction occurs in the absorption tower at temperature T_1. Solute rich solvent is preheated by exchange with hot regenerated solvent and transferred to the recovery tower. By increasing the temperature to T_2 the reaction is reversed, the volatile solute gas is recovered as the overhead and the regenerated solvent at the bottom. The regenerated solvent is cooled by exchange with the solute rich solvent and an auxiliary cooler and recycled to the absorption stage. An additional requirement of the reagent is that it be relatively nonvolatile.

Advantages gained by using a chemical reaction in the absorption process are functions of the characteristics of the reagent. These characteristics are:

1. Exhibit a high rate of reaction with the solute gas and have a reaction which is effectively irreversible over a specific temperature range.

2. Provide a reaction that is thermally reversible.

3. Exhibit relatively high diffusion rates through the solvent.

4. Be relatively nonvolatile compared with the solute gas.

5. Have a low equivalent reaction weight.

6. Does not significantly increase the viscosity of the carrier solvent in the range of concentrations utilized.

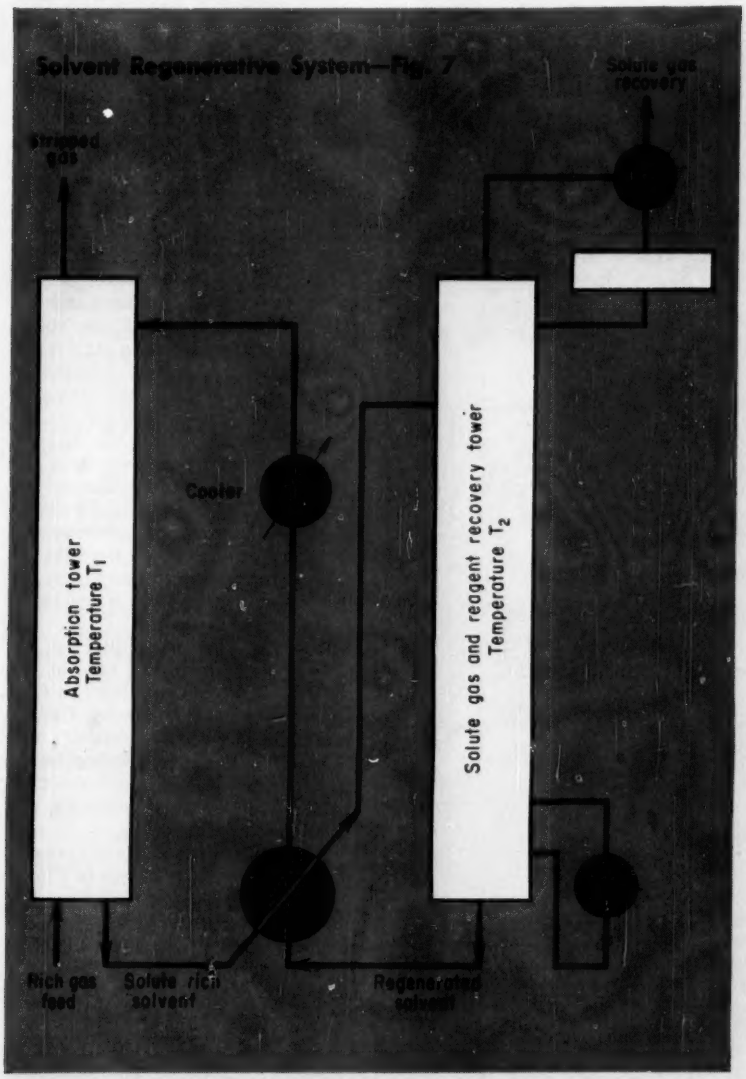
Advantages of a reagent offering these characteristics may be noted from an analysis of the behavior of systems in which absorption accompanies chemical reaction.

Reaction and Diffusion Rates

Effect of reaction rate on the over-all mass transfer rate was evaluated by Danckwerts[7] based on his work[6] and on the work of Hatta.[10] Using the two-film model, the penetration model and the surface renewal model, the following relationships were established for a first order or pseudo first order chemical reaction accompanying absorption.

Two-Film Model

$$k_L' = \frac{Dk_c}{\tan h(Dk_c/k_L)^{1/2}} \qquad (10)$$



Penetration Model

$$k_L' = (Dk_c)^{1/2}\left(1 + \frac{k_L^2}{8Dk_c}\right) \times \operatorname{erf}\frac{2}{k_L}\left(\frac{Dk_c}{\pi}\right)^{1/2} \qquad (11)$$

Surface Renewal Model

$$k_L' = (Dk_c + k_L^2)^{1/2} \qquad (12)$$

where k_L' is the absorption coefficient when chemical reaction occurs.

Via the three analyses, the effective liquid phase mass transfer coefficient k_L' is a function of a single parameter Dk_c/k_L^2 where D = diffusion coefficient of the solute gas in the solvent. k_c = reaction velocity constant. k_L = liquid film coefficient for the physical absorption.

If a comparison of the rate of absorption accompanied by chemical reaction is made on the basis of zero solute concentration in the bulk liquid phase—a situation necessary for the effectiveness of absorption accompanied by chemical reaction—then, via any behavior model:

$$k_L' = f(Dk_c/k_L^2) \qquad (13)$$

For a rapid chemical reaction where the parameter Dk_c/k_L^2 becomes large, the absorption becomes effectively gas-phase controlling and a maximum rate of absorption is achieved. This effect is most readily observed with the Danckwerts penetration model where

$$\frac{k_L'}{k_L} = \left(\frac{Dk_c}{k_L^2} + 1\right)^{1/2} \qquad (14)$$

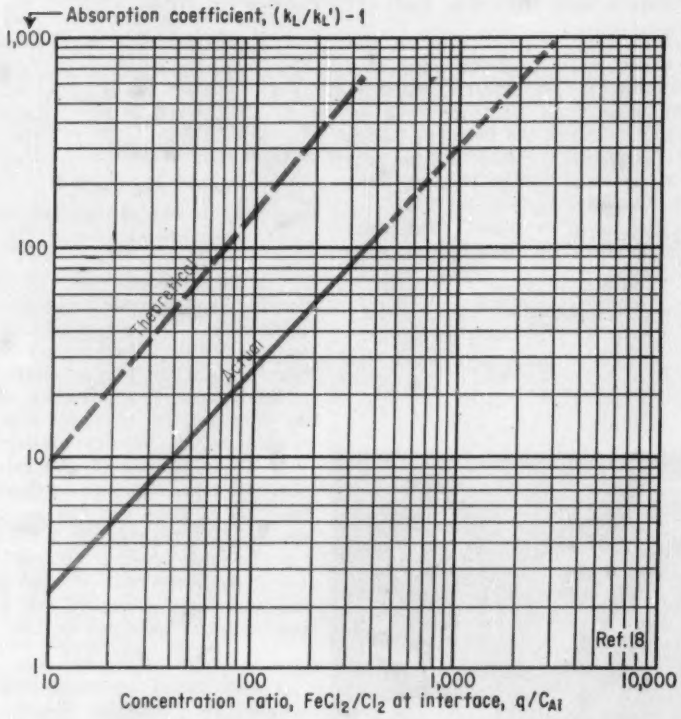
The ratio k_L'/k_L increases with increase in reaction rate k_c until the liquid phase resistance compared with that of the gas phase becomes negligible.

In the extreme case of a zero reaction rate, $k_L'/k_L = 1$ and no advantage in rate of absorption is gained. Thus, the advantage gained by the application of chemical reaction of first order or pseudo first order is highly dependent on the rate of reaction.

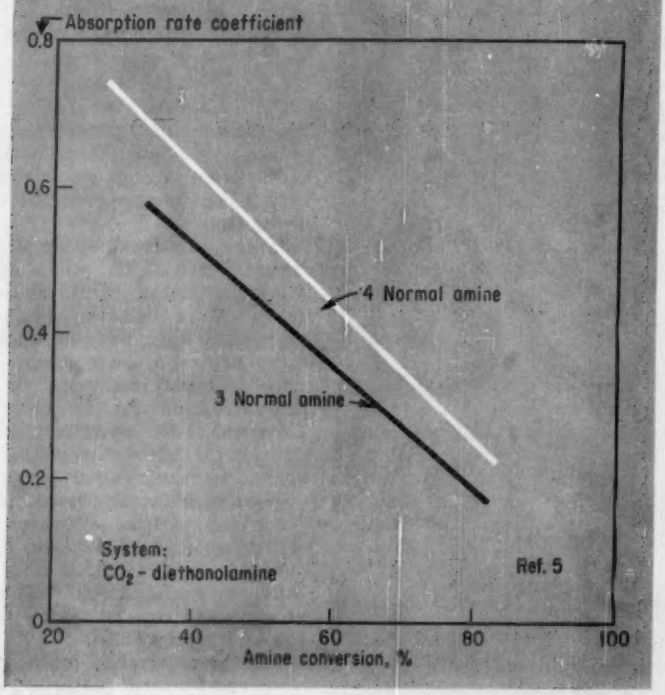
For the second order reaction accompanying chemical reaction, no analytical solutions have been developed without the use of simplifying assumptions. However, analytical solutions have been developed for specific conditions where the relative diffusivities of both solute gas and reagent in the liquid solvent are established.

Via the penetration model, Sherwood and Pigford[17] indicate that an approximation of the relative rate

Concentration Affects Absorption Coefficient—Fig. 8



Effect of Reagent Concentration on Coefficient—Fig. 9



of absorption accompanied by a rapid second order chemical reaction to that of the physical absorption process is as follows:

$$\frac{k_L'}{k_L} = \left(1 + \frac{D_B}{D_A}\frac{q}{C_{Ai}}\right) \quad (15)$$

Danckwerts[7] compared the behavior of three conditions for second order reaction where the rates of diffusion of solute gas and reagent in the liquid solvent are equal $(D_B/D_A = 1)$.

1. If $(Dk_2q/k_L^2) \ll 1$ (16)
   then $k_L' = k_L$ and no advantage is gained. (17)
2. If $(Dk_2q/k_L^2) \gg q/C_{Ai}$ (18)
   then $k_L' = [1 + (q/C_{Ai})]k_L$ (19)
3. If $1 \ll (Dk_2q/k_L) \ll q/C_{Ai}$ (20)
   then $k_L' = (Dk_2q)^{1/2}$ (21)

In condition 2, the reaction rate is so rapid that the rate of absorption is controlled by the diffusion of reagent and solute gas to the reaction site.

In condition 3, the concentration of the reagent is so high and the reaction rate so fast that the absorption approaches that of the first order reaction situation. Thus, where a second order reaction occurs, the availability of unreacted reagent, the concentration of the solute gas at the interface and the relative diffusivities of the solute gas and reagent become significant in the rate controlling process as indicated by Eqs. (15) through (21).

Effect of the ratio q/C_{Ai} is indicated in Fig. 8 based on data obtained by Stephens and Morris[18] for the system $FeCl_2(aq)$-Cl_2. The ratio of rate of absorption accompanied by chemical reaction to that of physical absorption approaches the approximate relationship indicated in Eq. (15).

Effect of the availability of unreacted reagent on the rate of absorption was obtained for the CO_2-diethanolamine system by Cryder and Maloney.[5] With increase in conversion of the diethanolamine to the carbonate, or the equivalent reduction in the availability of unreacted diethanolamine, a significant decrease in the mass transfer coefficient occurs as shown in Fig. 9.

For the first order reaction, the rate of absorption is directly proportional to the concentration of the unreacted solute gas at the interface. This advantage is not obtained in the second order reaction since an increase in concentration of un-

reacted solute gas at the interface will tend to remove available unreacted reagent (by reaction) in the region of the interface and move the reaction zone deeper into the liquid phase. Thus the penetration phenomenon will occur, causing a reduction in the rate of absorption. Where a second order reaction occurs, $k_L' \propto (1/C_{A1})$ as indicated by Eq. (15).

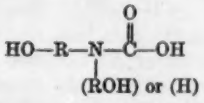
Therefore, in a commercial process it is economically desirable to choose a first order reaction or to attain a pseudo first order reaction via an excess of reagent in the solvent or by using low concentrations of solute gas in the gas stream.

Equivalent Weight of Reagent

An example of the effect of the equivalent weight of the reagent on the economics of absorption is made evident by a comparison of the three ethanolamines used in absorption of carbon dioxide.

		Mol. Wt
Monoethanolamine	$HOCH_2CH_2NH_2$	61.09
Diethanolamine	$(HOCH_2CH_2)_2NH$	105.14
Triethanolamine	$(HOCH_2CH_2)_3N$	149.19

It is believed that the mono and diethanolamines react with CO_2 by an electron donation of a hydrogen from the amine linkage forming carbamates as indicated by Goodridge.[9]



According to Jensen and others,[13] the triethanolamine provides the labile hydrogen from the OH linkage forming a carbonate.

$$N(CH_2CH_2OH)_3CH_2CH_2CO_3^-$$

In all cases, only one molecule of the amine is utilized per molecule of CO_2 reacted. Thus the relative equivalent weights used in the absorption mechanism are:

MEA:DEA:TEA = 1:1.72:2.44

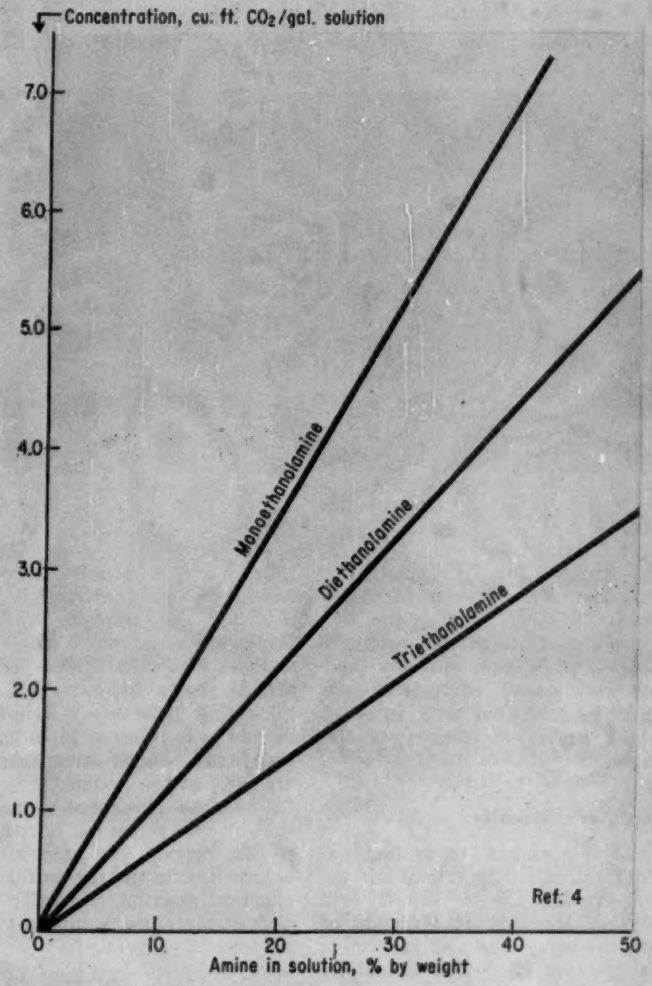
Relative absorption capacities of CO_2 per pound are:

in MEA:in DEA:in TEA = 1:0.58:0.41

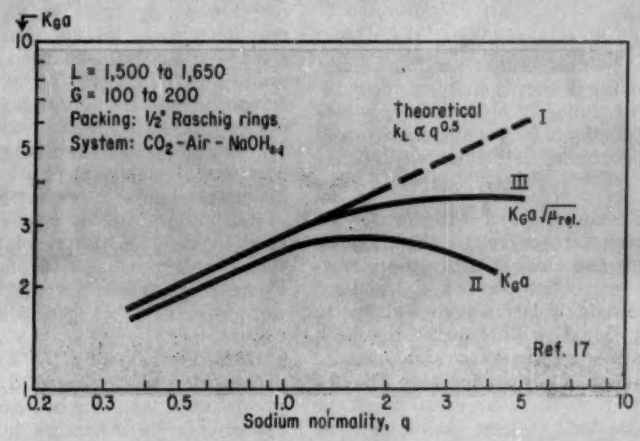
This relationship is confirmed by Connors[4] from commercial loading data and is illustrated in Fig. 10.

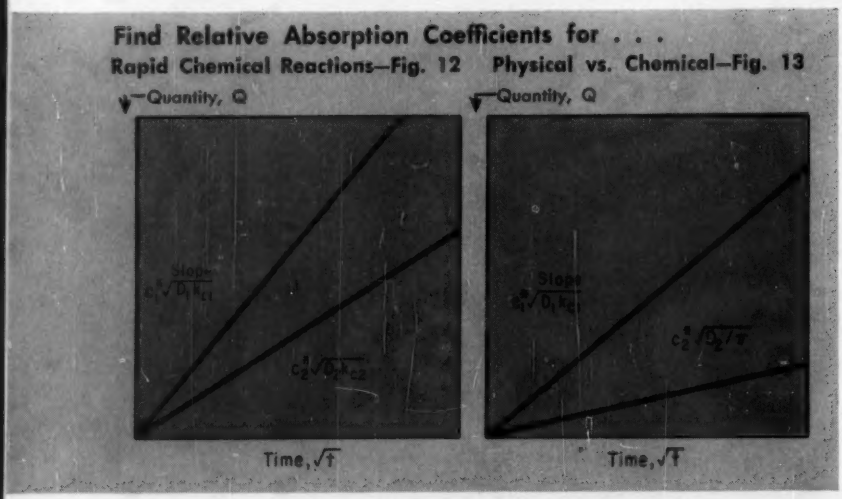
Inasmuch as the prices of all three materials are essentially the same (~ 24¢/lb.), the relative investment in raw materials would be

Compare Acid Gas Pickup of Ethanolamines—Fig. 10



Reagent Concentration Affects Mass Transfer—Fig. 11





72% greater for DEA than for MEA and 144% greater for TEA than for MEA.

In addition, if reaction rate and diffusion rates were constant (and they were lower), equipment sizes would be increased with increase in the equivalent weight of the reagent.

Effect of Viscosity

Use of a reagent on system viscosity will affect the rate of absorption. An increase in viscosity will decrease the rate of diffusion of both the solute gas and reagent to the reaction site. The diffusivity in a liquid is inversely proportional to the viscosity of the solution so that the effectiveness of the absorption is dramatically affected by change in viscosity.

As indicated in a first order or pseudo first order reaction accompanying absorption $k_L' = (Dk_c + k_L^2)^{1/2}$. Since $k_L^2 \propto D$, then k_L' is also proportional to D which is inversely proportional to the viscosity. Thus:

$$k_L' \propto (1/\mu)^{1/2} \qquad (22)$$

Sherwood and Pigford[37] attempted to correlate the data of Tepe and Dodge[30] using the viscosity correction in the CO_2-sodium hydroxide solution system shown in Fig. 11. It is anticipated that in a first order reaction system that k_L' or K_oa is proportional to the 0.5 power of the concentration of the unreacted reagent as shown by curve I. The data as given by curve II indicate significant deviation from anticipated behavior. Correction for the viscosity variation brings the data into better agreement with the anticipated behavior and is shown by curve III. The remaining difference is believed to be due to a decrease in interfacial area that results from increased viscosity of the system.

Thus, the increase of viscosity of the solvent system via introduction of the reagent can have a result antithetical to the reason for using chemical reaction. Viscosity variation is, therefore, significant in the choice of a reagent.

Using the Theoretical Models

As a result of the complexities involved in the mechanism of absorption accompanied by chemical reaction, no rigorous analytical method of design has been developed. But this is not unique in the field of chemical engineering process design. As a result of our need for immediate use knowledge, large numbers of empirical relationships have been developed for specific systems and a limited range of operating variables. Extrapolation of these relationships beyond the range of conditions for which they were developed can lead to erroneous results.

However, by using the concepts presented, we have a useful tool to predict effectively the behavior of a system for which design information is required, by comparison with the behavior of a system that has been evaluated.

In comparisons made for design purposes for physical absorption systems, the same hydrodynamic conditions for both systems are utilized. This is a reasonable approach since comparison at different hydrodynamic conditions complicates the calculation by superimposing the variation of interfacial area, time of penetration and degree of surface renewal.

Under the same hydrodynamic conditions the mass transfer rates between two systems can be compared via penetration theory analysis. From the penetration theory, Danckwerts[7] showed that:

$$\frac{k_1'}{k_2'} = \frac{Q_1}{Q_2} = \frac{\int_0^t \phi_1(t)\, dQ_1(t)}{\int_0^t \phi_2(t)\, dQ_2(t)} \qquad (23)$$

Since, under the same hydrodynamic conditions $\phi_1(t) = \phi_2(t)$, the comparison of the rate coefficients depends only on the relationship between the curves relating Q and t obtained from laboratory penetration data.

Suppose for example that the system to be evaluated is a rapid first order or pseudo first order reaction. Then the Q versus time curves would be similar to those indicated in Fig. 12. Hence:

$$\frac{k_1'}{k_2'} = \frac{c_1^*(D_1k_{c1})^{1/2}}{c_2^*(D_2k_{c2})^{1/2}} = \frac{dQ_{1(t)}/dt}{dQ_{2(t)}/dt} \qquad (24)$$

No specific data concerning reaction rates or diffusivities need be obtained but only the quantities of material absorbed as a function of exposure time.

If a comparison is made between a system undergoing physical absorption and one in which a first order reaction takes place, a similar analysis may be used. A typical example is shown in Fig. 13. Again the relative absorption coefficients may be obtained from the ratio of the slopes of the two curves or from diffusion data and reaction rates.

An approximative method for predicting the effect of chemical reaction on absorption rates was developed by vanKrevelen and Hoftijzer[21] based on the relationships of dimensionless groups. The effect of chemical reaction on the over-all absorption role is designated by a factor m based on the following:

For physical absorption:

$$Q/\theta_{ol} = k_L(c_i^* - c_L) \qquad (25)$$

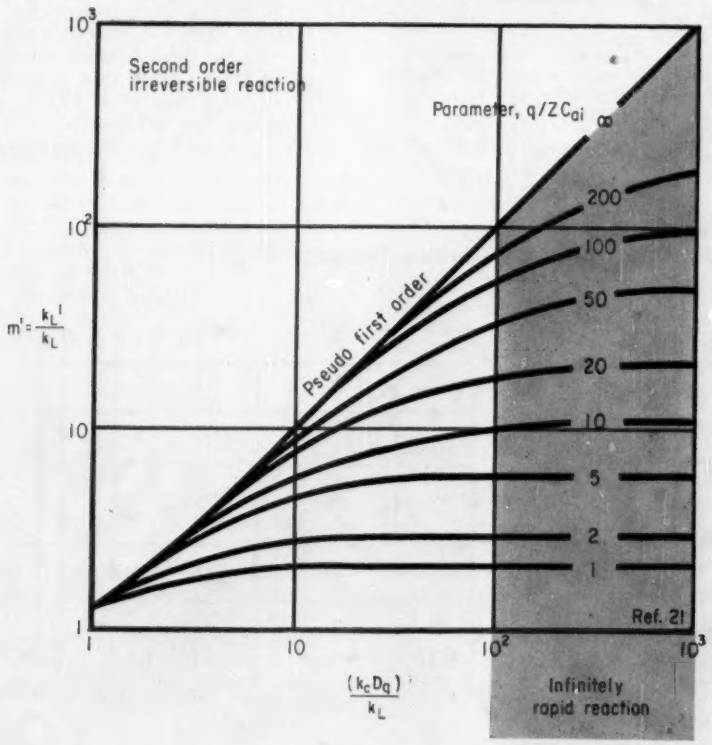
Absorption Rate Coefficients for Carbon Dioxide in Various Solvents—Table II

Solvent	Packing	L Lb./(Hr.)(Sq. Ft.)	G Lb./(Hr.)(Sq. Ft.)	$K_G a$ Lb. Mole/(Hr.)(Cu. Ft.)	Ref.
Water	1-in. Raschig rings	2,500	300	0.05	1
Sodium carbonate, 1N. (20% of sodium as bicarbonate)	1-in. Raschig rings	2,500	300	0.03	2
Diethanolamine, 3N. (50% conversion to carbonate)	¾-in. Raschig rings	2,500	300	0.04	3
Sodium hydroxide, 2N. (20% conversion to carbonate)	1-in. Raschig rings	2,500	300	2.3	4
Sodium hydroxide, 2N.	1-in. Berl saddles	2,500	263	1.9	5
Monoethanolamine, 2.5N. (40% conversion to carbonate)	1-in. Tellerettes	2,500	861	4.9	6
	1-in. Tellerettes	2,500	570	3.7	6
	1-in. Berl saddles	2,500	861	3.1	6
	1-in. Raschig rings	2,500	861	3.1	6
Potassium carbonate, 40% (50% conversion to carbonate)	½-in. Raschig rings	2,500	400	0.1–0.6	7

References
1. Sherwood and Holloway, *Trans. AIChE*, 36, 39 (1940).
2. Furnas and Bellinger, *Trans. AIChE*, 34, 251 (1938).
3. Cryder and Maloney, *Trans. AIChE*, 37, 287 (1941).
4. Tepe and Dodge, *Trans. AIChE*, 39, 255 (1943).
5. Spector and Dodge, *Trans. AIChE*, 42, 827 (1946).
6. Teller and Ford, *Ind. Eng. Chem.*, 50, 1201 (1958).
7. Benson, Field and Jimeson, *Chem. Eng. Progress*, 50, 356 (1954).

Comparison of system performance in Table II is not exact since the transfer rate is a function of the partial pressure of the carbon dioxide in the gas phase and the concentration of the unreacted reagent. These values vary from case to case as noted.

How Chemical Reaction Affects Absorption Rates—Fig. 14



For chemical reaction accompanying absorption:

$$Q/\theta_{ai} = mk_L(c_i^* - c_L) = k_L'(c_i^* - c_L) \quad (26)$$

Comparison under the conditions of zero solute concentration in the bulk of the liquid ($C_L = 0$), results in the ratio

$$(k_L'/k_L) = m' \quad (27)$$

Fig. 14 represents the relationship between the dimensionless groups of:

Rate of absorption when accompanied by chemical reaction to rate of physical absorption, or:

$$\frac{Q/\theta_{ai}}{k_L c_i^*} = m'$$

Ratio of reaction-diffusion rate to physical transfer rate equals:

$$(k_c Dq)^{1/2}/k_L$$

Ratio of relative concentrations of unreacted reagent and solute gas equals:

$$q/zC_{ai}$$

where z is equal to moles of reagent reacting with one mole of solute.

The curves in Fig. 14 represent graphically the effects indicated in

Eqs. (16) through (21) for a second order reaction phenomenon.

If the reaction rate is low $[(k_c Dq)^{1/2}/k_L] < 1$, then the absorption rate approaches that of physical transfer.

If such an excess of unreacted reagent exists that diffusion of the reagent is unnecessary, then $k_L' \propto k_c^{1/2}$ or the absorption rate is primarily a function of the rate of reaction. If the reaction rate is very great, then m' approaches q/zC_{at}.

Admittedly, there is a dearth of data on the absorption of gases accompanied by chemical reaction as a function of exposure time. Although obtaining penetration data is more complex than obtaining vapor-liquid equilibria, the advantages gained via such knowledge have great economic value. For example, via the use of chemical reaction in the absorption process coupled with surface regeneration a 100-fold increase in rate of absorption has been achieved as indicated in Table II.

To achieve the maximum economic advantage of absorption accompanied by chemical reaction, it is desirable that reaction mechanism and reaction kinetics be determined. If such data are not available, penetration studies such as described should be made for the general conditions of operation anticipated. Otherwise, there is danger of developing inoperable designs via extrapolation.

An example of such danger is indicated in experience with the system carbon dioxide-monoethanolamine. At low concentrations of CO_2 at the interface, and with an excess of the reagent present, the rate of reaction appears to be the rate controlling step and is dependent on the concentration of the reagent. The partial pressure of CO_2 does not have a significant effect on the coefficient k_L when the absorption rate is expressed in the traditional two-film method, $N_A = k_L(c^* - c_o)$. With increase in the partial pressure of CO_2, the diffusion of CO_2 in the liquid becomes significant in the rate controlling process and, therefore, the effect of the concentration of CO_2 at the interface has a greater effect on the diffusion rate coefficient.

Kohl[18] developed an empirical relationship incorporating the effect of CO_2 and monoethanolamine concentrations on the mass transfer coefficient based on data obtained by Shneerson and Leibush.[28] It was proposed that

$$K_G a \propto M(0.5 - c)e^{-3.4P} \qquad (28)$$

where

M = Molarity of MEA.
0.5 = Saturation concentration, moles CO_2/mole MEA.
c = Concentration, moles CO_2/mole MEA in solution.
$M(0.5 - c)$ = Corresponds to q in Eq. (15).
P = Partial pressure of CO_2 in gas phase.

The relationship was based on data obtained at one atmosphere with 3 to 5% CO_2 in the gas phase. Teller and Ford[29] found that the effect of the partial pressure of CO_2 on the mass transfer rate was insignificant in the range of a CO_2 partial pressure of 15 to 80 mm. Hg. This effect is shown in Fig. 15.

Kohl cautioned against general use of the relationship in Eq. (28), which is apparently correct for the range of partial pressures studied, by stating: "there is serious doubt as to whether the coefficient would decrease at the same rate at very high partial pressures of CO_2."

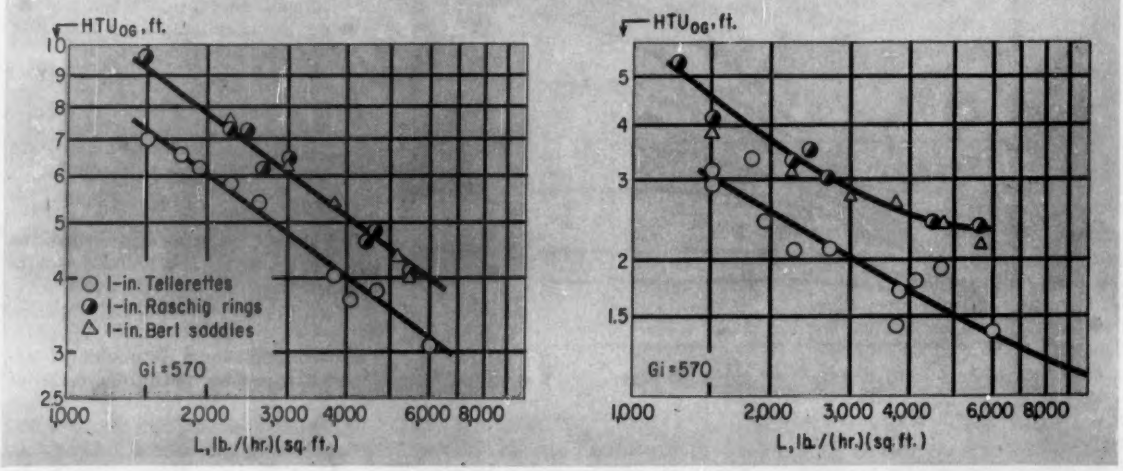
Although the exponential relationship proposed by Kohl indicates

Compare Extrapolated Values for Mass Transfer Rates—Table III

Pressure CO_2 Atm.	Ratio* When $K_G a = e^{-3.4P}$	$K_G a = P$
0.01	1	1
0.10	1.36	10
0.50	5.3	50
1.0	29	100
2.0	870	200
3.0	26,000	300

*Ratio of $H_{OG(P)}/H_{OG(1\ atm.)}$ from data obtained at 1 atm.

Behavior of CO_2-MEA System With Various Packings—Fig. 15



very little change of mass transfer at low partial pressures of CO_2, the exponential effect at high partial pressures of CO_2 exceeds the inverse linear relationship indicated in Eq. (15).

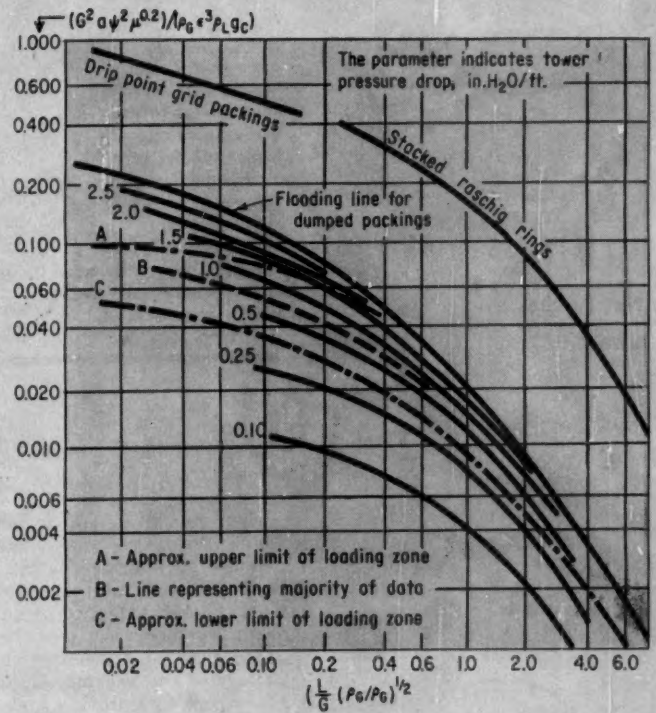
If an attempt was made to extrapolate the data available for the mass transfer rate established for the studies made at one atmosphere via the empirical relationship and via the theoretical relationships for a second order rapid reaction, the comparison shown in Table III is developed.

Via extrapolation of an empirical relationship based on one mechanism, it would appear that absorption of CO_2 at elevated operating pressures would be unfeasible. However, such operation is accomplished as indicated by the article of Gregory and Sharman.* Inasmuch as the authors reported on operating experiences rather than on a planned research evaluation, the data are not suitable for design purposes except for duplication of the existing unit. However, at partial pressures of CO_2 ranging from 40 to 1,600 mm., the average height of transfer unit was about twice that obtained by Teller and Ford. From the limited data, it appears that $K_g a \propto (q/C_{si})^{0.8}$. This relation approximates that anticipated for a rapid second order reaction accompanying chemical absorption.

Therefore, the diffusion-reaction system is different at low concentrations of CO_2 at the interface than when high concentrations exist. For more effective understanding of this problem and all other absorptions accompanied by chemical reaction, kinetic studies must precede effective design.

Economic selection of equipment as well as the estimation of kinetics based on a unit area of contact depends on the system behavior in absorption processes. For example, the previous discussion indicated that increase in time of exposure of a surface results in a decrease of the average rate of transfer in the liquid phase. Thus, if the liquid phase offers a significant fraction of the resistance to mass transfer, use of equipment providing a high rate of surface renewal (and the concomitant reduction in exposure time of a surface) will result in increased rates of transfer. Cost of power to achieve surface generation and renewal for the various

Find Packed Tower Flooding Velocities—Fig. 16

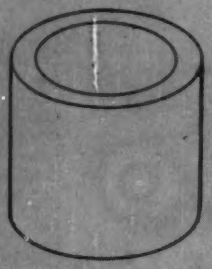


Characterization Factors of Packings—Table IV

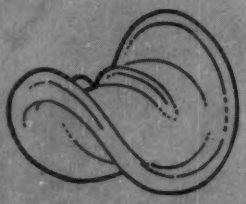
Packing	Nominal Size	Free Volume	Weight	C_f
	In.	%	Lb./Cu. Ft.	
Raschig rings	¾	67	46	182
(Stoneware)	1	68	45	155
	1½	68	45	97
	2	75	24	75
Berl saddles	¾	65	48	138
(Stoneware)	1	69	45	82.5
	1½	70	38	76
Intalox saddles	1	70	34	77
(Stoneware)	1½	81	30	81
Tellerettes				
(Polyethylene)				
Low density	1	83	10	65
High density	1	87	10	57
Raschig rings	1	92	73	115
(Steel, 1/16-in. thick)	2	92	38.7	75
Pall rings	1	93	33	45
(Steel)	2	94	28	17

Use these characterization factors with Fig. 16.

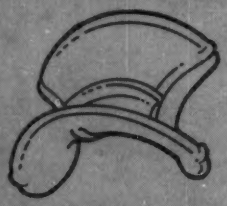
Raschig Ring



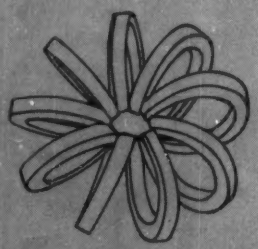
Berl Saddle



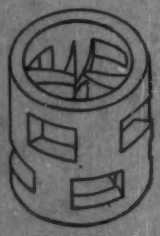
Intalox Saddle



Tellerette



Pall Ring



Costs of Representative Tower Packings—Table V

	Cost of Packing, $/Cu. Ft. (1959 Basis)			
	½-In.	1-In.	1½-In.	2-In.
Raschig rings, ceramic	11.70	6.50	5.05	4.85
Raschig rings, carbon	16.90	9.60	8.00	6.60
Berl saddles, ceramic	24.80	9.90	7.50	7.70
Intalox saddles, ceramic	23.55	9.40	7.15	7.30
Intalox saddles, carbon	.....	18.60	18.40	.....
Tellerettes, polyethylene				
Low density	.....	16.00	.....	.....
High density	.....	23.00	.....	.....
Pall rings, ceramic (BASF)	.....	5.00	.....	.....
Pall rings, polypropylene	41.00	26.00	20.75	18.50
Pall rings, stainless steel	186.50	96.00	83.00	69.00

types of equipment will also affect the selection.

In general, dispersion types of absorbers such as spray towers, cyclonic scrubbers and venturies provide a very large contact surface but insignificant surface renewal. Packed towers provide significant surface and a degree of surface renewal depending on the geometry of the packing. Extended surface packings provide high surface and moderate surface renewal. The discontinuous or filamentous type of packing provides a high degree of surface renewal.

In cases where the degree of absorption required exceeds 98% or where significant surface renewal is advantageous to the rate of absorption, the packed tower is generally selected. The specific advantage is that the number of transfer units may be varied with the column and is not restricted by the cocurrent mechanism as in the case of dispersion type contactors. In addition, the power consumption is lower than in other contactors.[14] In the packed tower, the power required per transfer unit is approximately 10% that of a spray tower and 1% that of a venturi.

Tower Packings

A large number of packings are commercially available, each having specific advantages of surface, regeneration, capacity and cost. Packing selection must be based on the mass transfer characteristics of the system and the power availability.

Comparative capacities of the various packings may be estimated from flooding or phase inversion velocities. The flooding characteristics reflect instability in column behavior. Phase inversion is related to a change of gas condition from the continuous to the dispersed phase, the column continuing to operate in a stable manner.

Flooding or phase inversion velocities may be obtained from Fig. 16 via a modified ordinate for the Sherwood and Hollaway relationship. A characterization factor C_f is used in place of the traditional a/F_p^3 function. This factor is based on experimental data rather than gross dry areas and free volumes. Characterization factors as well as free volumes and weights of the various packings are indicated in Table IV.

Relative flow capacities of the various packings may be estimated from the relationship:

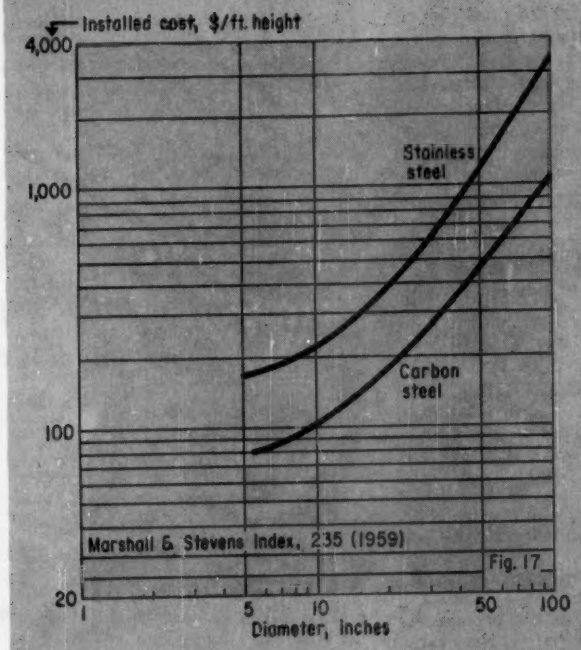
$$\frac{\text{Capacity Packing 1}}{\text{Capacity Packing 2}} = \frac{C_{f1}}{C_{f2}}$$

Costs of packings which may compose a major cost of the installation are found in Table V. Inasmuch as the selection of the packing will affect the tower diameter and height required, and the cost per unit height of tower, generalization of costs results in only rough approximations.

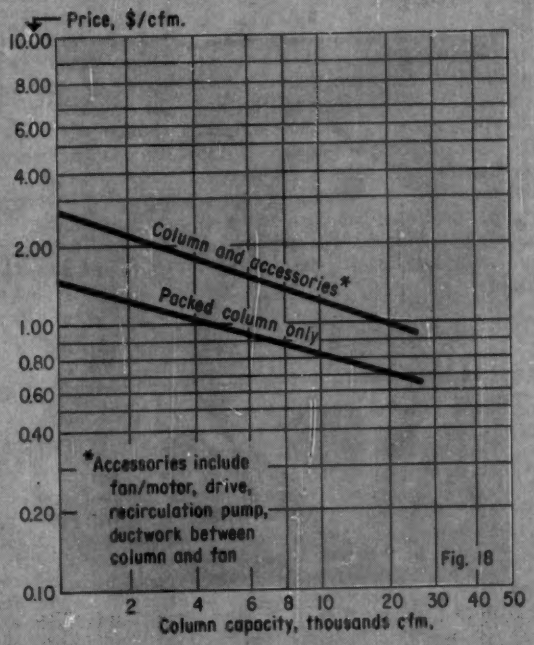
Aries and Newton[1] estimated the cost of packed towers as functions of diameter using Raschig rings as packing. Costs on the basis of 1959 indexes are shown in Fig. 17.

Arndt[2] presented a generalization of costs of plastic shell columns using combinations of Dowpac and Tellerette packings. The costs are

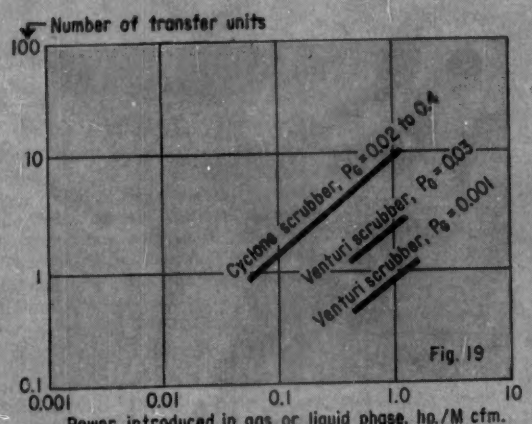
Estimate Packed Column Costs

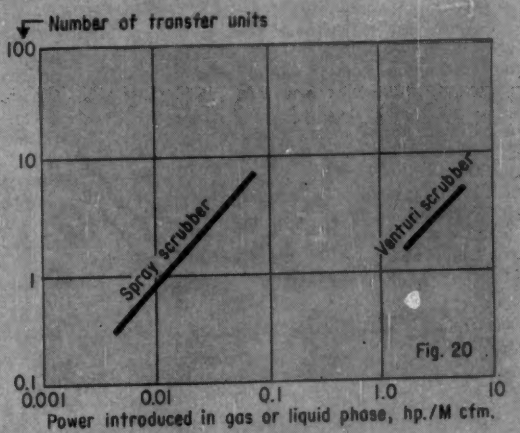


Plastic-Packed Fume Scrubber Prices



Compare Relative Power Requirements of Scrubbers





based on provision of five transfer units for 95% recovery and a gas-phase controlling absorption. These costs are shown in Fig. 18.

Spray Systems

Spray contacting devices generally represent the least expensive installations for mass transfer. As a result of (1) mixing of the liquid sprays with the gas stream, (2) entrainment of spray by the gas stream and (3) effectively parallel flow in most designs, spray type absorption units are not generally applicable to systems where true countercurrent flow is required.

Thus, high solubilities are required in spray systems because the number of transfer units available is limited. Spray contacting units have been found applicable to systems where highly soluble gases accompany solids that must be removed from a gas stream.

In spray towers and cyclone spray towers, the liquid dispersion is created by mechanical power consumption in the liquid phase. In venturi scrubbers, the liquid dispersion is developed via power provided by the gas phase. In jet scrubbers, the liquid dispersion and the gas pumping are provided by the liquid phase power input.

A comparison of power consumption for a cyclone scrubber and venturi scrubber by Lunde[14] is shown in Fig. 19 and that of a spray tower with a venturi in Fig. 20.

Nomenclature

a	Gross geometric area of packings, sq. ft.
C_L	Concentration of solute gas in bulk liquid phase, lb. mole/cu. ft.
c^*	Equilibrium concentration of solute gas in bulk gas phase, lb. mole/cu. ft.
C_{Li}	Equilibrium concentration of solute gas at interface, lb. mole/cu. ft.
D	Diffusivity, sq. ft./hr.
G	Gas flow rate, lb./(hr.) (sq. ft.).
G_m	Gas flow rate, lb. mole/(hr.) (sq. ft.).
H_G	Height of gas phase transfer unit, ft.
H_L	Height of liquid phase transfer unit, ft.
H_{OG}	Height of over-all gas phase transfer unit, ft.
k_r	Reaction rate constant, lb.-ft.-sec. units.
K_Ga	Over-all mass transfer coefficient, lb. mole/(hr.) (cu. ft.) (atm.).
K_La	Over-all mass transfer coefficient, lb. mole/(hr.) (cu. ft.) (lb. mole/cu. ft.).
k_Ga	Gas phase mass transfer coefficient, lb. mole/(hr.) (cu. ft.) (atm.).
k_La	Liquid phase mass transfer coefficient, lb. mole/(hr.) (cu. ft.) (lb. mole/cu. ft.).
k_{La}	Liquid phase mass transfer coefficient, lb. mole/(hr.) (sq. ft.) (lb. mole/cu. ft.).
k_L	Liquid phase mass transfer coefficient when accompanied by chemical reaction, lb. mole/(hr.) (sq. ft.) (lb. mole/cu. ft.).
L	Liquid flow rate, lb./(hr.) (sq. ft.).
L_m	Liquid flow rate, lb. mole/(hr.) (sq. ft.).
m	Slope of solubility equilibrium line, dy^*/dx.
N_A	Mass transfer rate, lb. mole/(hr.) (cu. ft.).
p^*	Equilibrium partial pressure of solute gas in bulk solvent, atm.
p_G	Partial pressure of solute gas in bulk gas phase, atm.
P	Partial pressure, atm.
Q	Quantity of solute gas transferred, lb. mole.
q	Concentration of unreacted reagent, lb. mole cu. ft.
s	Surface renewal rate.
t_r	Penetration time, hr.
U_s	Superficial gas velocity at flooding, fps.
v	Volume of transfer zone, cu. ft.
x	Mole fraction of solute gas in liquid phase.
y	Mole fraction of solute gas in gas phase.
ρ	Density, lb./cu. ft.
μ	Viscosity, lb./(hr.) (ft.) or lb./(sec.) (ft.).
θ	Total time for penetration, hr.

Subscripts

A	Component A.
B	Component B.
f	Film condition.
G	Gas phase.
i	At interface.
L	Liquid phase.

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Austenitic Stainless Steels

Thousands of Tons in −300 to −425 F. Service

J. H. McCONNELL, U. S. Steel Corp., Pittsburgh, Pa. R. R. BRADY, U. S. Steel Corp., Monroeville, Pa.

Chromium-nickel stainless steels are inherently suitable for service at the extreme subzero temperatures of −300 to −425 F.

Other materials discussed in this series (carbon steels, May 30, 1960, p. 103; alloy steels, June 27, 1960, p. 119) are not capable of standing up to such temperatures.

The thousands of tons of stainless used in liquid-oxygen production and storage testify to its practicality for service at −320 F. One investigator[3] showed why stainless is so popular in this field: after a 15-yr. exposure in liquid-oxygen service, a Type 303 valve stem still had an impact strength of 25 ft.-lb. at −295 F.

Missile-Proved Stainless

As another example, Type 304 stainless is used extensively in the construction of liquid oxygen, nitrogen and helium tanks, and for auxiliary piping at many ICBM installations. At one site, there are 12 low-temperature, double-walled storage tanks, each holding 28,000 gal. Inside shell is stainless.

Certainly, as low-temperature processing extends more and more into the chemical processing industries, stainless steels must be given prime consideration as construction materials.

The original cost of a stainless steel may be somewhat higher than other materials. But ease of fabrication (no heat treatment) and

AISI % Composition Limits for Important Subzero Austenitic Stainless Steels—Table I

Type	C, Max.	Mn, Max.	P, Max.	S, Max.	Si, Max.	Cr	Ni	Cb
302	0.15	2.00	0.045	0.030	1.00	17.00–19.00	8.00–10.00	...
304L	0.03	2.00	0.045	0.030	1.00	18.00–20.00	8.00–12.00	...
304	0.08	2.00	0.045	0.030	1.00	18.00–20.00	8.00–12.00	...
310	0.25	2.00	0.045	0.030	1.00	24.00–26.00	19.00–22.00	...
347	0.08	2.00	0.045	0.030	1.00	17.00–19.00	9.00–13.00	10xC min.

Low-Temperature Impact Properties of Annealed Austenitic Stainless Steels—Table II

Type	Specimen Orientation	Type of Notch	Plate Size, In.	Test Temperature, °F.	Impact Strength, Ft.-Lb.
304	Longitudinal	Keyhole	3	−320	80
304	Transverse	Keyhole	3	−320	80
304	Transverse	Keyhole	2½	−320	70
304	Longitudinal	Keyhole	½	−425	80
304	Longitudinal	V notch	3½	−425	91.5
304	Transverse	V notch	3½	−425	85
304L	Longitudinal	Keyhole	½	−320	73
304L	Transverse	Keyhole	½	−320	43
304L	Longitudinal	V notch	3½	−320	67
304L	Longitudinal	V notch	3½	−425	66
310	Longitudinal	V notch	3½	−320	90
310	Transverse	V notch	3½	−320	87
310	Longitudinal	V notch	3½	−425	86.5
310	Transverse	V notch	3½	−425	85
347	Longitudinal	Keyhole	½	−320	60
347	Transverse	Keyhole	½	−320	47
347	Longitudinal	V notch	3½	−425	59
347	Transverse	V notch	3½	−425	53
347	Longitudinal	V notch	6½	−300	77
347	Transverse	V notch	6½	−300	58

◀ **LIQUID HYDROGEN** at −425 F. carried in stainless-lined tanker.

welding, combined with high strength and excellent shock resistance, even under abnormal conditions, go far toward offsetting this higher initial expenditure. These advantages result in an economic justification for stainless steels in cryogenic applications at temperatures as low as −425 F. Actually, austenitic stainless steels are now performing satisfactorily for the storage of liquid hydrogen at −425 F.

If the pressure-vessel code would recognize the increase in strength of stainless steels at low temperatures, additional savings in material costs would be realized.

Low-Temperature Stainlesses

Table I lists the AISI chemical compositions generally used in subzero service. Type 304 is, by far, the most popular of the five grades shown.

The primary criterion generally considered for materials used at low temperature is notch toughness. Recently, the U. S. Steel Corp. conducted an extensive series of impact and tension tests on several austenitic stainless steels at −320 and −425 F. The results of the impact tests, summarized in Table II, show that annealed stainless steel retains excellent impact values at temperatures as low as −425 F. Note too, that the chemical composition, section size, specimen ge-

How Prolonged Subzero Exposure Affects Type 304 Stainless—Table III

Type	Time of Exposure	Test Temperature, °F.	Charpy Keyhole-Notch Impact Strength, Ft.-Lb.
304	0	−320	85.0
	30 min.	−320	72.5
	6 mo.	−320	73.0
	12 mo.	−320	75.0

Tensile Properties Actually Improve at Low Temperatures —Table IV

Type	Test Temperature, F.	Yield Strength (0.2% Offset), Psi.	Tensile Strength, Psi.	Elongation in 2 in., %	Reduction in Area, %
304	+ 75	33,000	85,000	60	70
304	−320	57,100	205,500	43	45
304	−425	63,700	244,500	48	43
304L	+ 75	28,000	85,000	60	60
304L	−320	35,000	194,500	42	50
304L	−425	33,900	220,000	41	57
310	+ 75	45,000	95,000	60	65
310	−320	84,900	157,500	54	54
310	−425	115,500	177,500	56	61
347	+ 75	35,000	90,000	50	60
347	−320	41,200	186,000	40	32
347	−425	45,500	210,500	41	50

Coefficient of Expansion: Very Little Change at Low Temperatures—Table V

Type	Test Temperature, °F.	Coefficient of Linear Expansion In./in./F. x 10^{-6}
304	−100 to 70	8.2
	−200 to 70	7.7
	−300 to 70	7.4
347	−100 to 70	8.5
	−200 to 70	8.1
	−300 to 70	7.5
310	−100 to 70	7.8
	−200 to 70	7.5
	−300 to 70	7.0

Modulus of Elasticity: Good Down to Minus 320 F.—Table VI

Type	Test Temperature, °F.	Modulus of Elasticity in Tension, 10^6 Psi.
302	−320	27.2
304	−320	26.2
347	−320	27.0

Note: Extremely low temperatures have little effect on stainless steel's coefficient of expansion or modulus of elasticity.

ometry, and orientation have no serious effect on impact properties. Likewise, Table III shows that good impact strength is retained after prolonged low-temperature exposure.[7]

Strength Increases

Results of tension tests shown in Table IV indicate that the excellent ductility (elongation and reduction of area) of chromium-nickel stainless steels is retained, even though the strength level increases substantially at the low temperature.

The high strength and ductility of notched-tension specimens is further evidence of the outstanding notch toughness of stainless steel.[1] This increase suggests the possibility of savings in material costs if vessel design could be based on the properties at the operating temperature (the practice used in designing for elevated temperature) rather than on the properties at room temperature.

Extremely low temperatures have no unusual effect on the modulus of elasticity or coefficient of expansion, as is shown in Tables V and VI.[7]

Watch for Carbides

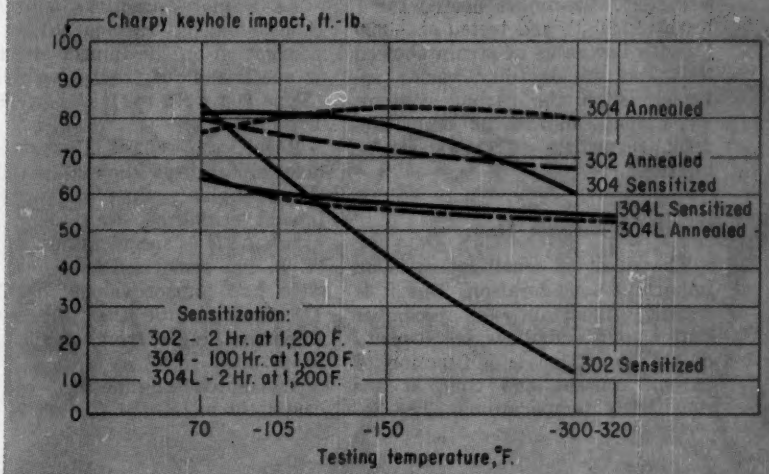
Formation of intergranular chromium carbides (known as sensitization) can occur in varying degree in several of these stainless compositions. The severity of sensitization depends on:

- Carbon content of the stainless.
- Exposure time in the range 900 to 1,500 F.

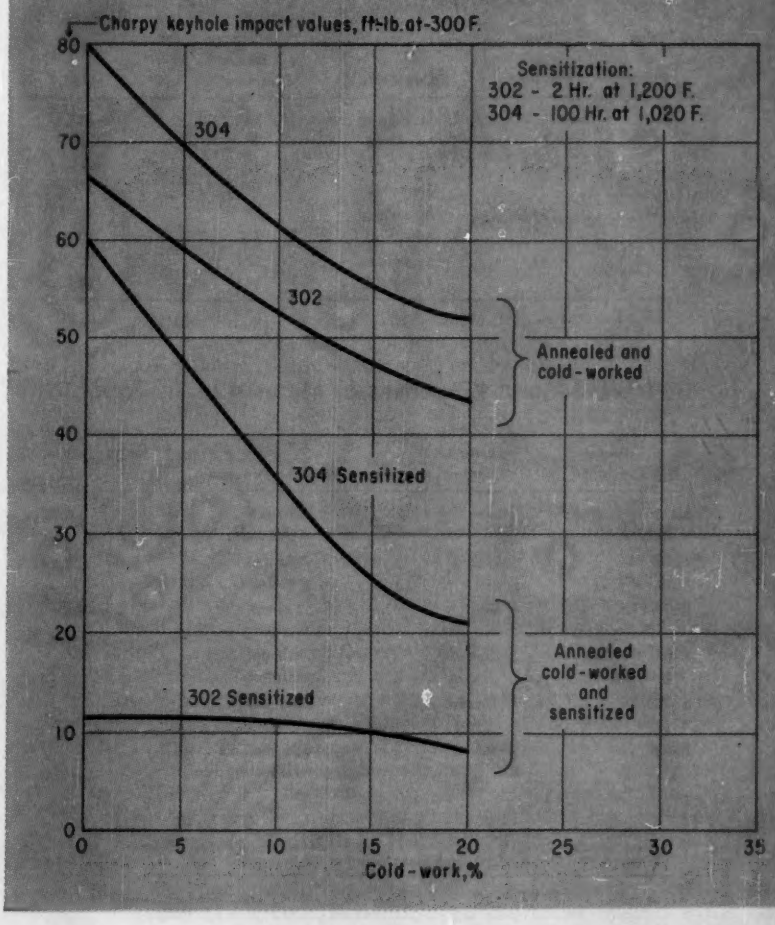
Such exposure occurs in the heat-affected area adjacent to welds. Fig. 1 shows that the impact properties of Type 302 at −300 F. are impaired by sensitization but Types 304 and 304L with lower carbon remain at a high impact level after sensitization.

The combined effect of cold work and sensitization[3] is plotted in Fig. 2. With severe sensitization plus substantial cold work—a rare situation in actual practice—the impact strength of Type 304 is still above the 15 ft.-lb. minimum requirement of the ASME boiler code. Binder[3] has shown that Type 304 stainless can be cold-worked at −320 F. up to 20% without reducing the impact strength below code requirements.

Annealing, Sensitization Affect Stainless Toughness—Fig. 1[7]



Cold Working Sensitized Stainless Lowers Toughness—Fig. 2[3]



Work by Kramer and Baldwin[4] demonstrates the significance of carbon content on the low-temperature ductility of sensitized stainless steel. Specimens heated for 1 hr. at 1,200 F. and tested at −320 F. with low rates of strain showed that loss in ductility varies inversely with the carbon content. Type 304L showed no embrittlement regardless of the speed of testing.

Practical Impact Data

The effect of sensitization is an important consideration. But it is equally important to remember that, as outlined above, the severity of this condition is a function of carbon content and time at the sensitizing temperatures. The information detailed above is from laboratory tests deliberately treated to represent extreme conditions unusual in actual fabrication.

As a more practical approach, U. S. Steel has carried out an investigation on the impact strength of specimens cut from a weldment (Type 304 weld rod) of ½-in. thick Type 304 plate.

Results of −302 F. Charpy keyhole impact tests show all areas of the wrought product exhibit good impact strengths, well above the usual ASME specifications of 15 ft.-lb. The sensitized area near the weld had impact values of 36 to 113 ft.-lb., while the parent-weld interface ranged from 66 to 71 ft.-lb.

The notch toughness of the as-cast weld metal (24 ft.-lb.) is significantly lower than that of the wrought metal, but still above code requirements for subzero service.

Krivobok and Thomas[5] data on weld metal in Table VII show a similar level of impact strength. Annealing after welding improved the strength in some instances. The weld-metal properties of Type 304 tested at −425 F. in Table VIII are of particular interest. Even at this extremely low temperature, stainless steel in the cast condition can tolerate a latitude in welding practice and still retain more than adequate toughness for normal design standards.

Weld Metal Holds Up at Minus 320 F.—Table VII

Type of Plate	Type of Electrode	Condition	Charpy Keyhole Impact Values, Ft.-Lb. Room Temperature	−320 F.
304	304	As welded	34	20
		Annealed	45	35
304	308	As welded	32	17
		Annealed	36.5	30
347	347	As welded	27	19
		Annealed	25	18
310	310	As welded	37	23.5
		Annealed	31	19

304 Weld-Metal Properties at Minus 425 F.—Table VIII

Electrode Class	Electrode Coating	Welding Process	Charpy Keyhole Impact Strength,* Ft.-Lb.
E308-15 (0.07% C)	Lime	Manual metal-arc	17
E310-15 (0.11% C)	Lime	Manual metal-arc	23
E308L-15 (0% Ferrite)	Lime	Manual metal-arc	20
E308L-15 (4% Ferrite)	Lime	Manual metal-arc	27
E308L-16 (4% Ferrite)	Titania	Manual metal-arc	27
E308L	None	Inert-gas-shielded consumable-electrode metal-arc†	37

* Values are the average of quadruplicate specimens.
† Inert welded using a mixture of 45 cu. ft. of argon/hr. and 4.5 cu. ft. of nitrogen/hr. (Courtesy of the Graver Tank and Manufacturing Co.)

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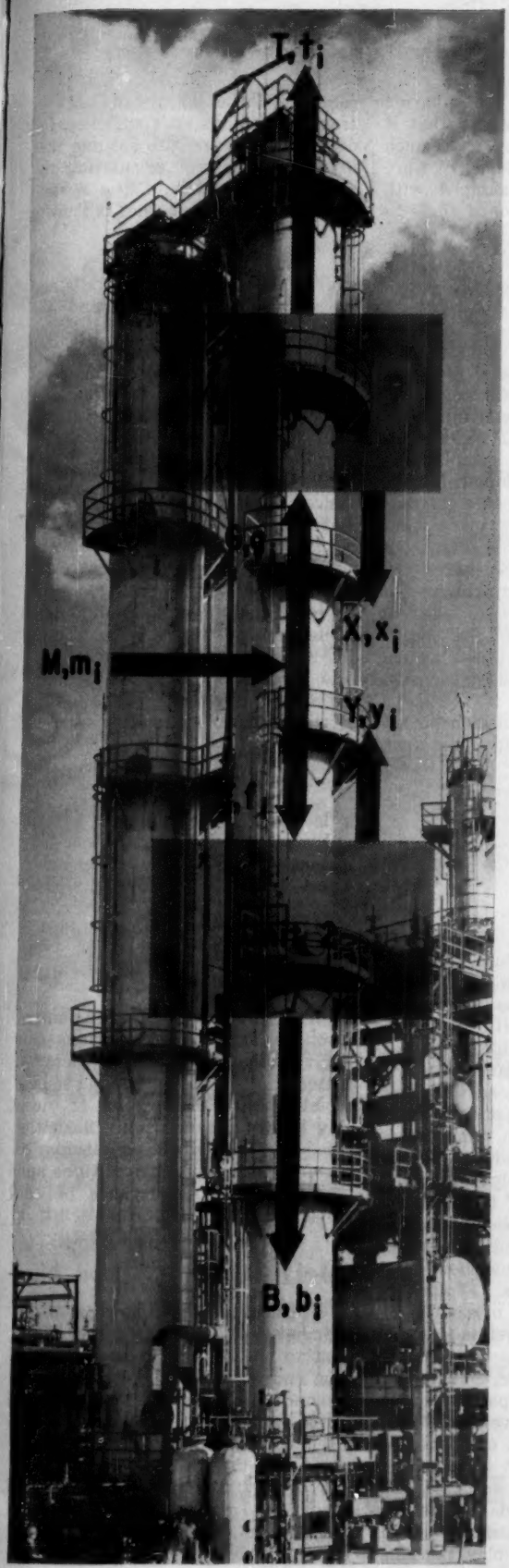

Better Computer Solution of Multi-ComponentSystem

A new method is proposed for faster-converging solutions for distillation columns.

A. M. PEISER, The M. W. Kellogg Co., New York, N. Y.

Multi-component distillation tower calculations are difficult because the process of arriving at the solution is, of necessity, an iterative one. Since it's not possible to define in advance the state of the tower at any point, calculation is customarily begun by assuming conditions at some point and carrying out tray-to-tray calculations through the tower. The resulting trial solution will, in general, fail to satisfy over-all thermodynamic conditions imposed upon the tower.

New conditions must then be assigned and the entire procedure repeated until complete balance is attained. Key to successful solution of the problem lies in convergence or "closure," i.e., the manner in which new conditions are assigned after each unsuccessful pass through the tower. With growing use of high-speed computers for distillation calculations and resulting improved accuracy in tower design, the need for rigorous methods of closure has become increasingly evident.

We present here a new method of tower closure. This method has been in productive use on the M. W. Kellogg Co. computer for over two years and has been applied to rating and design of several hundred towers. Concerning convergence, we can report that the method has never failed to lead to the correct solution. A rigorous proof of convergence hasn't been found for the general case, but we have been able to prove that the procedure will converge under mildly restrictive mathematical conditions that can be reasonably well satisfied in actual practice.[1]

What makes the method particularly attractive is its rapid rate of convergence. In particularly insensitive cases, two passes through the tower suffice. On the average, and depending upon the particular appli-

cation, four or five passes are sufficient. It's a rare case that requires more than seven or eight passes through the tower.

Although the calculation method has been developed specifically for the calculation of distillation towers, it will be apparent that it actually can be applied to a much broader class of problems. We are not concerned, for example, with the internal mechanism of the system—with the details of tray-to-tray calculations. It's sufficient for our purpose merely to assume that a means exists for calculating the state at one point of the system when the state at another is known.

Description of the System

We are basically concerned with a system of the sort represented by the schematic diagram on page 129. It consists, as indicated, of processing units 1 and 2 linked by stream X flowing from 1 to 2 and stream Y flowing from 2 to 1. Feed M enters between the units with one part G going to unit 1 and the remainder F going to unit 2. Products T and B are drawn from units 1 and 2 respectively. We need not specify in detail the actual performance of units 1 and 2. For our purpose, it is sufficient merely to assume, for example, that if B is known we can calculate Y and if T is known we can calculate X.

The system described in the foregoing is recognizably a distillation tower. (Think of units 1 and 2 as sequences of equilibrium stages and of the manner of determining Y from B and X from T as the customary tray-to-tray calculation.) In the following development, however, no further reference to tray-to-tray calculations is made. The results are perfectly general for any system as described here.

Performance can, in principle, be set by the assignment of "size" of each process unit and the energy input to each unit. These fix the four degrees of freedom for such systems.

Two types of calculations interest us in process design: the "rating" case, in which "size" and energy input are given and the products are to be determined; and the "design case, in which one energy input and a key component in each product stream are given and the "size" is to be determined. The method of calculation described here is applicable to both cases.

Throughout the article, we observe the following conventions of nomenclature. Upper-case letters (e.g., X) refer to molal flow rates of total streams; the associated lower-case letters (e.g., x_i) refer to mol fractions of individual components in the stream. Each stream contains r components, and the subscript i will always range from $i = 1$ to $i = r$. The symbol Σ will indicate summation over all components.

Concept of Pseudo-Volatilities

To explain the new procedure, let's consider the simplest of processing schemes, the equilibrium flash. A feed M, with component breakdown in mol fractions m_i ($\Sigma m_i = 1$), enters a flash chamber from which emerge a liquid product and a vapor product.

In keeping with the notation of the figure on p. 129, we call total flows of these products B and T and their mol fractions as b_i and t_i respectively. Material balance requirement for each component provides the relationships

$$Mm_i = Bb_i + Tt_i \qquad (1)$$

$$\Sigma b_i = 1, \quad \Sigma t_i = 1 \qquad (2)$$

Liquid and vapor are further related by thermodynamic equilibrium and can be expressed most conveniently by the familiar concept of equilibrium K values.

$$t_i = K_i b_i \qquad (3)$$

Clearly, if K_i is known, then these three equations represent a fully determined system from which B, b_i, T, t_i can be calculated directly.

If, however, only the relative values of the K's are known—say $K_i = C\alpha_i$, where the α_i are relative volatilities and C is an unknown parameter—then Eq. (3) becomes

$$t_i = C\alpha_i b_i \qquad (4)$$

The system of Eqs. (1), (2) and (4) has no unique solution because, in addition to the flows, the parameter C must also be determined. One additional condition must be set to define the problem. For example, an energy balance might be required, in which case the determination of C corresponds to determination of the flash temperature.

Our closure method can now be described most simply by viewing the entire system of the figure on p. 129 as a very complex flash chamber. There is a feed stream, a bottom product and an overhead product which satisfy Eqs. (1) and (2). In the closure case, of course, we do not have equilibrium between the products in the conventional thermodynamic sense, but we can conceive some "pseudo-equilibrium" in which overhead-to-bottoms ratio for each component is set in some way by internal performance of the system itself.

This thinking leads to the concept of "pseudo-volatilities" which satisfy Eq (4) and play the same role in our complex system as conventional relative volatilities play in a conventional flash. The additional degree of freedom implied by Eq. (4) can be absorbed in a variety of ways depending upon requirements of the problem. We shall deal with some of the usual cases later on.

With this concept, the entire problem of tower calculations can be thought of as the problem of determining the proper pseudo-volatilities of the system. If these are known, we need only flash the feed at prescribed conditions to determine the outlet conditions and the complete performance of the tower.

Definition

Throughout the following development, we suppose that energy input to one of the process units of the figure is known and that of the second unit is determined by overall energy balance. In a tower, this means that a reflux or associated heat duty is given.

To start the iterations, we assume trial values for the product streams, B, b_i and T, t_i. It's certainly reasonable to suppose that

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Stainless steels can be bent, drawn, and roll-formed by all the standard techniques known in the metalworking industry. In these operations, stainless requires somewhat greater power and harder tools than it takes to work softer materials. But this characteristic stems directly from stainless steel's superior ability to withstand bending and denting in service.
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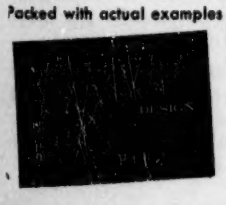

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these will be selected in a manner consistent with the over-all material balances, Eqs. (1) and (2). If "size" of the process units is known, we can determine by appropriate calculations within the units the quality of effluent streams, x_i and y_i. Effluent flow rates X and Y can then be chosen to satisfy the gross material balance

$$X - Y = B - F = G_j - T_j \quad (5)$$

and the energy balance around either of the process units.

Starting with trial values of the product streams, therefore, we obtain values for the "connecting" streams that are consistent with detailed performance requirements of the process units, that satisfy energy balance for each unit and that satisfy the *gross* material balance, Eq. (5), for each unit.

For these trial values to be the correct solutions to the problem, the units must be in material balance with respect to each individual component

$$Xx_i + Tt_i = Yy_i + Gg_i$$
$$Xx_i + Ff_i = Yy_i + Bb_i \quad (6)$$

In general, these equalities will not be satisfied, and we must seek new trial values B', b_i' and T', t_i'. We do this by flashing the feed as described above. For the "volatilities" of the flash, we want relations of the form

$$\alpha_i = (l_i/b_i)\theta_i \quad (7)$$

where the θ's are defined so that $\theta_i = 1$ when Eq. (6) is satisfied. For then the *new* values of the products will be the same as the *old* ones, and the final solution will have been reached.

This suggests that the ratios of the left to right hand sides of Eqs. (6) should enter into the definition of the θ's. Furthermore, if a given set of t_i/b_i leads to mismatch in favor of one process unit, we would want the values of t_i'/b_i' to tend in the opposite direction. If, for example,

$$Yy_i + Gg_i < Xx_i + Tt_i$$

we should expect t_i to be decreased and b_i increased for the next iteration. We would want the i-th component to be less "volatile" and so should have $\theta_i < 1$.

From these considerations, we might infer that in the definition of θ_i, the right-hand sides of Eqs. (6) appear in the numerator and the left-hand sides in the denominator. From such heuristic reasoning, we have found it convenient to define θ_i as follows

$$\theta_i = \sqrt{\frac{Yy_i + Gg_i}{Xx_i + Tt_i} \cdot \frac{Yy_i + Bb_i}{Xx_i + Ff_i}} \quad (8)$$

This form of θ_i is, of course, quite arbitrary, and undoubtedly other satisfactory representations can be found.

Our experience with Eq. (8) indicates that it induces rapid convergence in all cases. The underlying significance of Eq. (8) in the convergence process is shown in the mathematical proof of convergence given in Ref. 1. As the process converges, not only do the θ's approach 1, but the parameter C of Eq. (4) approaches 1 as well. We have found the value of C to be a convenient measure of the rate of convergence.

Procedure for Rating Case

For the rating problem, the "size" of each unit and the energy input to one of them are known. The additional degree of freedom is usually fixed by either assigning the flow ratio T/B or the mol fraction of a key component. We proceed as follows

1. Select trial values for B, b_i and T, t_i that are consistent with Eqs. (1) and (2).
2. Calculate through the process units to obtain x_i, y_i.
3. Determine X, Y from the overall energy balance and the *gross* material balance around one unit.
4. Calculate pseudo-volatilities from Eqs. (7) and (8). If resulting θ's are sufficiently close to unity, stop the calculation.
5. Flash the feed, subject to the assigned condition of the problem (either product flow rate or recovery of one key component), and return to step 2.

If T/B is given, determination of the constant C of Eq. (4) corresponds to determination of the flash temperature. If a key component is given, the flash is slightly unconventional, but again the system is fixed, and solution is easy.

Procedure for Design Case

In the design case, energy input to one unit and mol fraction of a key component in each product stream are specified. The additional degree of freedom is taken up by the condition that the combined "size" of the process units be a minimum. This is more complex than the rating case—we must determine the size as we calculate through the process units.

Let b_k, t_k denote assigned values of the key component. The method employed here supposes (as in a tower) that a fairly sharp degree of separation is achieved in the process. Most components other than the keys are found in negligible quantities in one of the product streams, with a very small number of components (including the keys) being distributed between the products.

Another way of putting it is that if b_k and t_k are given, flow rates B and T are virtually known, changes due to influence of other components being quite small. This means that we know b_k and t_k, values of the keys in opposite product streams, to a good degree of approximation, and that for successive iterations the ratios t_k/b_k and t_k/b_k will be essentially unchanged.

If we now rewrite Eqs. (4) and (7) in the form

$$(l_i/b_i)_{new} = C\theta_i(l_i/b_i)_{old}$$

we see that for the key components

$$C\theta_k \approx C\theta_k \approx 1$$

or of greater significance

$$r_{k,k} = \theta_k/\theta_k \approx 1 \quad (9)$$

If we flash the feed in the same manner as in the rating problem, holding to, say, the value of b_k, and if Eq. (9) is satisfied, then it follows that the desired value of t_k will also be maintained. The design problem thus reduces to finding "sizes" for the process units in such a way that Eq. (9) is satisfied.

Note that for processes consisting of discrete steps, it's not generally possible to satisfy Eq. (9). In these cases we try to satisfy

$$r_{k,k} \leq 1 \quad (9a)$$

thus assuring that the calculated value of t_k does not exceed its specified value.

Our design procedure follows:

1. Assume a "size" for process unit 2 and a set of trial values of the product streams consistent with Eqs. (1) and (2).

2. Calculate y_i.

3. For successively increasing "sizes" of unit 1, calculate x_i, X, Y and $r_{h,k}$ until Eq. (9) or Eq. (9a) is satisfied. This gives a possible combined "size" for this iteration.

4. By varying "size" of unit 2, find the minimum combined size for this iteration. (This can be trial-and-error that is easily programmed for a computer.)

5. Calculate pseudo-volatilities from Eqs. (7) and (8). If the resulting θ's are sufficiently close to unity, stop the calculation.

6. Flash the feed subject to assigned value of b_k. Because of Eq. (9) or Eq. (9a), assigned values of t_k will not be exceeded. Return to step 2.

In some sense, condition of Eq. (9) corresponds to the conventional matching of the keys as the feed-point criterion in tower design. In our procedure, however, this matching serves only to guide the calculations with ultimate selection of feed point based upon rigid requirement of minimum size.

Numerical Example

To illustrate application of this method in an actual tower, we'll examine a typical case solved on the M. W. Kellogg Co. computer. A rating case, the data for the tower are given in Table I. Six theoretical trays are below the feed and six above. Reboiler duty was assigned, and bottom flow was to be 61.47% of feed, 614.7 mol/hr.

Computation was begun by assigning the trial values for bottoms and overhead compositions shown in column 1 of Tables II and III. Note that for the lighter-than-light and heavier-than-heavy keys, arbitrarily small concentrations were assigned.

These components are important in setting conditions in the vicinity of the feed and must be known with reasonable accuracy. The method of calculation brings them into line very quickly, however, so that no particular care need be taken in the original assumptions. Since overestimation of these components can cause difficulties in tray-to-tray calculations, it's preferable to deliberately underestimate them as has been done here.

Successive calculated bottoms and overheads are shown in Tables II and III. Although four trials were adequate for this case, several additional passes were made for purposes of final comparison.

Feed Conditions for Sample Tower Calculation—Table I

Component	Mol Fraction Liquid	Mol Fraction Vapor
1	0.00007	0.00609
2	0.00055	0.01173
3	0.00634	0.06497
4	0.00841	0.04938
5	0.02918	0.1384
6	0.03772	0.09933
7	0.05916	0.1367
8	0.1869	0.2243
9	0.2759	0.1712
10	0.2076	0.07057
11	0.1049	0.01856
12	0.08317	0.00874
mol/hr.	831.20	168.80

Convergence of Bottoms Compositions—Table II

Component	Mol Fraction				Final Value
	Run 1	Run 2	Run 3	Run 4	
1	2×10^{-24}	0.207×10^{-15}	0.103×10^{-15}	0.132×10^{-15}	0.136×10^{-15}
2	2×10^{-24}	0.631×10^{-11}	0.248×10^{-11}	0.339×10^{-11}	0.356×10^{-11}
3	2×10^{-24}	0.330×10^{-8}	0.126×10^{-8}	0.161×10^{-8}	0.166×10^{-8}
4	2×10^{-24}	0.219×10^{-6}	0.769×10^{-7}	0.892×10^{-7}	0.876×10^{-7}
5	2×10^{-24}	0.347×10^{-5}	0.988×10^{-6}	0.124×10^{-5}	0.124×10^{-5}
6	2×10^{-24}	0.293×10^{-3}	0.660×10^{-4}	0.722×10^{-4}	0.706×10^{-4}
7	2×10^{-24}	0.1100×10^{-2}	0.231×10^{-3}	0.244×10^{-3}	0.238×10^{-3}
8	0.04600	0.03864	0.04231	0.04167	0.04164
9	0.3920	0.3983	0.3957	0.3963	0.3963
10	0.3001	0.2998	0.2998	0.2999	0.2999
11	0.1470	0.1470	0.1470	0.1470	0.1470
12	0.1149	0.1149	0.1149	0.1149	0.1149
mol/hr.	614.70	614.70	614.70	614.70	614.70

Convergence of Overhead Compositions—Table III

Component	Mol Fraction				Final Value
	Run 1	Run 2	Run 3	Run 4	
1	0.00282	0.00282	0.00282	0.00282	0.00282
2	0.00632	0.00632	0.00632	0.00632	0.00632
3	0.04214	0.04214	0.04214	0.04214	0.04214
4	0.03977	0.03977	0.03977	0.03977	0.03977
5	0.1236	0.1236	0.1236	0.1236	0.1236
6	0.1249	0.1249	0.1248	0.1248	0.1248
7	0.1875	0.1858	0.1871	0.1871	0.1871
8	0.4281	0.4399	0.4341	0.4351	0.4351
9	0.04480	0.03486	0.03399	0.03804	0.03800
10	4×10^{-24}	0.408×10^{-3}	0.388×10^{-3}	0.332×10^{-3}	0.318×10^{-3}
11	4×10^{-24}	0.129×10^{-5}	0.150×10^{-5}	0.132×10^{-5}	0.127×10^{-5}
12	4×10^{-24}	0.182×10^{-7}	0.227×10^{-7}	0.208×10^{-7}	0.201×10^{-7}
mol/hr.	385.30	385.30	385.30	385.30	385.30

Convergence of Volatility Factors, θ_i—Table IV

Component	Trial Run 1	2	3	4
1	1×10^{-3}	1.348	0.818	1.001
2	4×10^{-15}	1.710	0.763	0.986
3	9×10^{-28}	1.755	0.821	0.991
4	1×10^{-17}	1.911	0.900	1.025
5	8×10^{-19}	2.362	0.833	1.006
6	1×10^{-20}	2.989	0.956	1.025
7	3×10^{-21}	3.218	0.992	1.021
8	1.147	0.606	1.063	0.997
9	0.922	0.756	1.018	1.004
10	$1\times10^{+23}$	0.639	0.896	0.976
11	$4\times10^{+19}$	0.785	0.921	0.978
12	$6\times10^{+17}$	0.837	0.959	0.983
Convergence Factor, C	1.204	0.672	1.045	0.9998

Convergence of Feed Point Vapor Compositions—Table V

Component	Mol Fraction Run 1	Run 2	Run 3	Run 4	Final Value
1	0.135×10^{-13}	0.927×10^{-4}	0.517×10^{-4}	0.729×10^{-4}	0.733×10^{-4}
2	0.422×10^{-15}	0.992×10^{-3}	0.386×10^{-3}	0.576×10^{-3}	0.593×10^{-3}
3	0.117×10^{-17}	0.01121	0.00538	0.006893	0.007071
4	0.314×10^{-19}	0.01648	0.00872	0.01004	0.009869
5	0.792×10^{-39}	0.07352	0.02827	0.03491	0.03520
6	0.208×10^{-21}	0.1356	0.04941	0.05229	0.05155
7	0.101×10^{-21}	0.2395	0.08432	0.08533	0.08440
8	0.5124	0.2150	0.4085	0.3835	0.3877
9	0.3681	0.2270	0.3152	0.3203	0.3191
10	0.09111	0.06154	0.07617	0.08078	0.07966
11	0.01954	0.01330	0.01624	0.01742	0.01713
12	0.00888	0.00572	0.00734	0.00782	0.00770
mol/hr	696.66	1,331.38	855.81	897.42	885.13

Convergence of Feed Point Liquid Compositions—Table VI

Component	Mol Fraction Run 1	Run 2	Run 3	Run 4	Final Value
1	0.104×10^{-4}	0.120×10^{-4}	0.112×10^{-4}	0.114×10^{-4}	0.113×10^{-4}
2	0.992×10^{-4}	0.112×10^{-3}	0.105×10^{-3}	0.106×10^{-3}	0.106×10^{-3}
3	0.00144	0.00154	0.00145	0.00147	0.00148
4	0.00253	0.00265	0.00252	0.00255	0.00255
5	0.01003	0.01045	0.00993	0.01007	0.01009
6	0.02149	0.02159	0.02072	0.02103	0.02109
7	0.03905	0.03853	0.03724	0.03781	0.03794
8	0.3357	0.3238	0.3089	0.3167	0.3186
9	0.5897	0.4050	0.4332	0.4405	0.4440
10	0.178×10^{-31}	0.1574	0.1422	0.1283	0.1239
11	0.104×10^{-19}	0.02774	0.03065	0.02864	0.02766
12	0.314×10^{-18}	0.0117	0.01309	0.01285	0.01254
mol/hr.	479.94	1,114.87	639.30	680.91	668.62

The final solution, as shown in the tables, does not differ significantly from the fourth trial. It's interesting to note that the extreme components, despite arbitrarily small assignments for trial 1, have the correct order of magnitude as early as trial 2.

Pseudo-volatility factors θ_i of Eq. (8) are given in Table IV. Extreme values for trial 1 reflect the arbitrary assignment of starting compositions. By trial 4, all θ's are quite close to unity, indicating the degree of matching at the feed point. Convergence factor C is also shown in Table IV. We have found the approach of C to unity a very reliable guide in assessing degree of convergence of the entire problem.

Finally, to illustrate the power of this method, we show in Table V the successive compositions of vapor at the feed point (stream X of figure on p. 129. Since the feed point is the most sensitive portion of the tower, convergence here is relatively more difficult to obtain.

Agreement between the fourth trial and the final solution, though not as good as at the ends of the tower, is well within the requirements of design accuracy. Using the numerical values given in Tables V and VI, you will be able to follow through the calculation of the θ's in Table IV and the successive product compositions in Tables II and III.

REFERENCES

1. Peiser, A. M., Convergence in a Special Class of Multivariate Systems Arising in the Design of Distillation Columns, submitted for publication to *J. Soc. Ind. & Appl. Math.*

A. M. PEISER heads up computer applications for M. W. Kellogg. With the company since 1954, he previously had seven years experience in the process industry. Educated at Brooklyn College and Cornell University, he took his Ph.D at the latter. In addition to daytime vocational duties, Dr. Peiser has served as adjunct asst. professor at Hofstra College and as lecturer at Stevens Institute of Technology. Professional affiliations include Society for Industrial & Applied Mathematics, American Mathematics Society and Association for Computing Machinery.

To analyze and solve the unsteady state heat transfer problems involving simultaneous first-order differential equations . . .

Use Numerical Mathematics

SAM H. DAVIS, JR., Rice Institute, Houston, Tex.*

Nearly all problems in unsteady state heat transfer involve the solution of simultaneous ordinary differential equations or a partial differential equation. The number of problems which can be described by a single first-order differential equation is limited to those in which a single temperature defines the state of the system involved.

The engineer who is interested in the field of unsteady state heat transfer must be familiar with techniques that can be adapted to a wide variety of problems. The ease with which numerical methods may be adapted to many problems of varying complexities makes such methods a valuable tool for the engineer. The previous article in this series (*Chem. Eng.*, June 13, 1960, p. 213) illustrated methods which can be used to find numerical solutions for a single first-order differential equation. Only a few additional techniques are necessary to develop numerical methods that can be used for the solution of more complicated and more practical problems than those considered in the previous article.

Numerical solution of partial differential equations involves the use of some finite difference approximation to substitute sets of ordinary differential equations for the original equations. Therefore, the subject of this article is the solution of simultaneous first-order differential equations. The solution of Fourier's heat conduction equation will then serve as an example for our next article of the numerical methods which can be employed in the solution of partial differential equations.

Simultaneous Differential Equations

Extension of polynomial approximations to the solution of simultaneous differential equations is quite straightforward. For general first-order ordinary differential equations the numerical method may be given as follows. Assume N differential equations are given:

$$\begin{aligned}
\frac{dy_1}{dt} &= F_1(t, y_1, y_2 \cdots y_N) \\
\frac{dy_2}{dt} &= F_2(t, y_1, y_2 \cdots y_N) \\
\frac{dy_n}{dt} &= F_n(t, y_1, y_2 \cdots y_N) \\
\frac{dy_N}{dt} &= F_N(t, y_1, y_2 \cdots y_N)
\end{aligned} \tag{1}$$

with the initial conditions at $t = t_0$ of

$$\begin{aligned}
y_1 &= y_1^0 \quad \text{and} \quad y_2 = y_2^0 \\
y_n &= y_n^0 \quad \text{and} \quad y_N = y_N^0
\end{aligned} \tag{2}$$

After t is divided into increments and the independent variable re-defined such that

$$\begin{aligned}
t &= s\,\Delta t \\
t_k &= k\,\Delta t
\end{aligned} \tag{3}$$

where s is a continuous variable and k is an integer, polynomial approximations in s may be found for each of the functions: $F_1, F_2 \ldots F_N$. If a second order approximation for each F is to be used, these approximations would take the form:

$$\begin{aligned}
F_n(t_1 y_1 \cdots y_n) \cong F_n(s) = {} & \\
& \tfrac{1}{2}(s-k-1)(s-k-2)F_n[t_k, y_1(t_k) \cdots y_N(t_k)] - \\
& (s-k)(s-k-2)F_n[t_{k+1}, y_1(t_{k+1}) \cdots y_N(t_{k+1})] + \\
& \tfrac{1}{2}(s-k)(s-k-1)F_n[t_{k+2}, y_1(t_{k+2}) \cdots y_N(t_{k+2})]
\end{aligned} \tag{4}$$

where the times t_k, t_{k+1} and t_{k+2} have been chosen for the determination of the polynomials. To simplify the notations in Eq. (4), the following abbreviations will be used:

$$\begin{aligned}
F_{nk} &\equiv F_n[t_k, y_1(t_k) \cdots y_N(t_k)] \\
y_{nk} &\equiv y_n(t_k)
\end{aligned}$$

In the above notation, Eq. (4) becomes:

$$\begin{aligned}
F_n(s) = {} & \tfrac{1}{2}(s-k-1)(s-k-2)F_{nk} - \\
& (s-k)(s-k-2)F_{nk+1} + \tfrac{1}{2}(s-k)(s-k-1)F_{nk+2}
\end{aligned} \tag{5}$$

Eq. (5) may be used to determine the approximate

* To meet your author, see *Chem. Eng.*, Apr. 18, 1960, p. 188.

change in y_n over the interval t_{k+3} to t_{k+4} or the interval t_{k+1} to t_{k+2}. Use of Eq. (5) for extrapolation over t_{k+2} to t_{k+3} leads to an open numerical approximation while its use for interpolation over t_{k+1} to t_{k+3} leads to a closed numerical approximation.

Integration of Eq. (5) over the interval t_{k+3} to t_{k+4} leads to the open approximation

$$y_{nk+4} - y_{nk+3} \cong \frac{\Delta t}{12}\,[5F_{nk} - 16F_{nk+1} + 23F_{nk+2}] \qquad (6)$$

Since the solution of Eq. (6) for y_{nk+4} requires knowledge for values of y_n at only t_{k+3}, t_{k+2} and t_k, the application of Eq. (6) is obvious. A step by step process is followed in which values of all the dependent variables may be determined from previously calculated values. However, since Eq. (6) requires knowledge of the dependent variables at three preceding time intervals and only one set is specified at time zero, two additional sets must be calculated by some auxiliary method such as discussed in *Chem. Eng.*, June 13, 1960, p. 213.

Use of Eq. (5) to derive a closed numerical approximation can be carried out in the same manner as in the derivation of the open approximation. If Eq. (5) is integrated between the limits t_{k+1} and t_{k+3} the following result is obtained:

$$y_{nk+3} - y_{nk+1} \cong \frac{\Delta t}{12}\,[5F_{nk+3} + 8F_{nk+1} - F_{nk}] \qquad (7)$$

Solution of the N equations of the form represented by Eq. (7) can be quite complicated since the values of F_{nk+3} for each n depend upon the unknown dependent variables y_{nk+3}. The set of simultaneous equations which must be solved may be given in abbreviated form as:

$$\begin{aligned} y_1 - aF_1[t, y_1, y_2 \cdots y_N] &= b_1 \\ y_2 - aF_2[t, y_1, y_2 \cdots y_N] &= b_2 \\ y_N - aF_N[t, y_1, y_2 \cdots y_N] &= b_N \end{aligned} \qquad (8)$$

where $a = 5\Delta t/12$, the b_N's are constants which can be calculated from previously determined values of the dependent variables and the subscript $(k + 2)$ has been omitted on the functions for conciseness. If the functions F_n are linear in the dependent variables y_n, Eq. (8) may be solved as simultaneous linear algebraic equations. In this latter case, we may write:

$$aF_n = C_{n1}y_1 + C_{n2}y_2 \cdots + C_{nj}y_j + \cdots C_{nN}y_N + a_n \qquad (9)$$

where the c_{nj}'s depend at most on time and would be evaluated at t_{k+3} in the present example. Substitution of Eq. (9) into Eq. (8) gives:

$$\begin{aligned} (1-C_{11})y_1 - C_{12}y_2 - \cdots - C_{1j}y_j \cdots - C_{1N}y_N &= b_1 + d_1 \\ (1-C_{22})y_2 - C_{21}y_1 - \cdots - C_{2j}y_j \cdots - C_{2N}y_N &= b_2 + d_2 \\ -C_{N1}y_1 \cdots + (1-C_{NN})y_N &= b_N + d_N \end{aligned} \qquad (10)$$

Even in cases where the F_n's are linear in the dependent variables, the solution of Eqs. (10) may be impractical if the number of simultaneous equations is large and the number of coefficients c_{nj} which are zero is small. However, if either of these conditions is not true, the solution of Eq. (10) may be feasible as is illustrated in the example given later.

Further, if the functions F_n are nonlinear in the dependent variables some iterative process must be used for the solution of Eq. (8). An iterative method which converges quite rapidly in cases where deviations from linearity are small may be devised in the same manner as for the solution of a single differential equation. This iterative method may be quite lengthy for the general problem in the solution of simultaneous equations. But, it may be feasible if either the number of equations is small or F_n depends on only a few of the dependent variables.

The extension of the methods discussed in this section to the solution of ordinary differential equations that involve derivatives of the dependent variable higher than the first may be simply accomplished by re-defining the dependent variables in the problem. For example, if one equation is of the form:

$$\frac{d^n y}{dt^n} = F\left[\frac{d^{n-1}y}{dt^{n-1}}, \cdots \frac{dy}{dt}, y, t\right] \qquad (11)$$

we may define the new dependent variables as:

$$u_{n-1} = \frac{d^{n-1}y}{dt^{n-1}},\ u_{n-2} = \frac{d^{n-2}y}{dt^{n-2}} \cdots u_1 = \frac{dy}{dt}$$

so that Eq. (11) is replaced by the equivalent set of simultaneous first order equations:

$$\begin{aligned} \frac{du_{n-1}}{dt} &= F[u_{n+1} \cdots u_1, y, t] \\ \frac{du_{n-2}}{dt} &= u_{n-1} \\ du_1/dt &= u_2 \quad \text{and} \quad dy/dt = u_1 \end{aligned} \qquad (12)$$

Higher derivatives than the first are rarely encountered in unsteady heat transfer, but may be introduced in the development of an over-all energy balance for a system which includes the acceleration of mass.

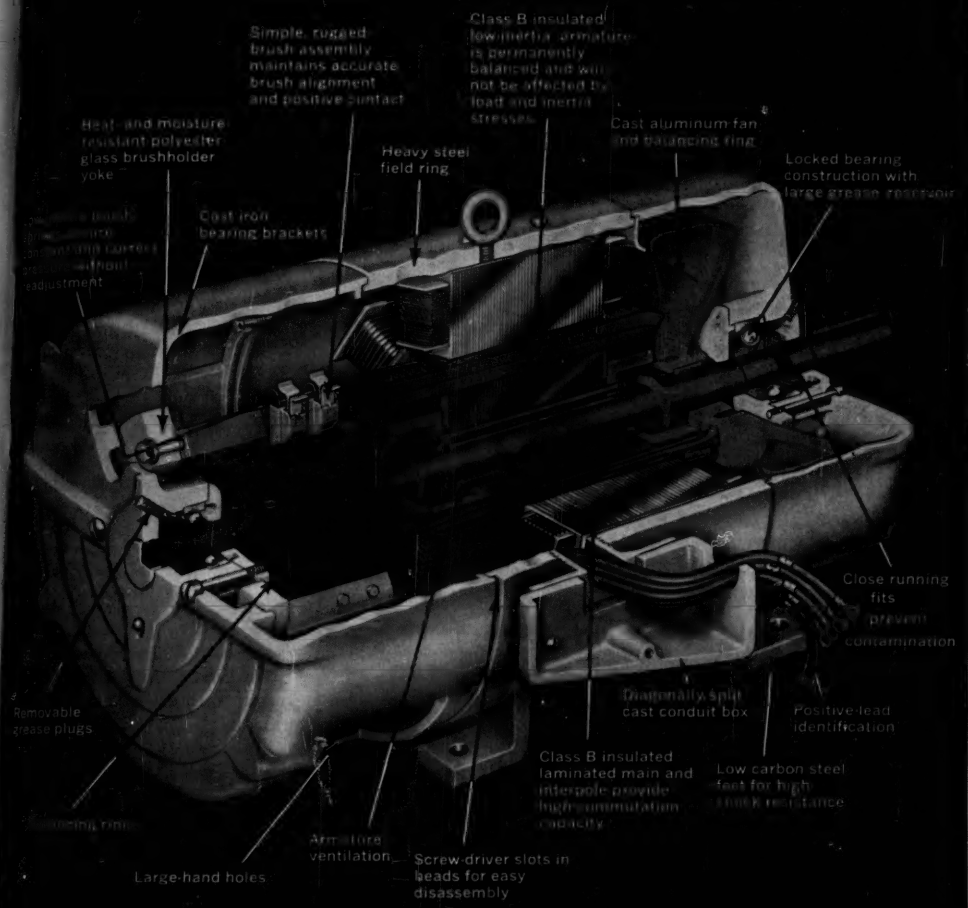
Example of Unsteady Heat Transfer

Many unsteady heat transfer problems involve more than one dependent variable. Examples of such problems are: (1) cascaded heat exchangers arranged so that the fluid flowing out of one exchanger forms the feed to the next exchanger; (2) heat exchangers in which the temperature of both the coolant and heating fluid change with time; and (3) stirred tank reactors in which energy is released or absorbed by a chemical

Nomenclature

c	Heat capacity.
F	Function.
k	Integer indicating time measured in units of Δt.
L	z-dimension of solid from centerline to each surface.
n	Integer indicating distance measured in units of Δx.
Q	Heat transfer rate.
R	Rate of reaction.
s	Continuous variable indicating time measured in units of Δt.
t	Time.
u	Continuous variable indicating distance measured in units of Δx.
V	Volume.
v	Volumetric flow rate.
x	Concentration.
y_n	Dependent variables.
z	Distance from centerline in solid.
ΔH	Heat of reaction.
θ	Temperature variable, dimensionless.
ξ	Concentration variable, dimensionless.
ρ	Fluid density.
ϕ	Independent time variable, dimensionless.
ψ	Reaction rate variable, dimensionless.
Ω	Heat transfer rate variable, dimensionless.

Here's the latest in D-C motor design: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reaction at a rate dependent on both temperature of the fluid and the concentrations of the reactants. The last of these problems will serve as an example of the numerical solution of simultaneous differential equations.

The set of differential equations which describe the behavior of a stirred tank reactor are derived from mass and energy balances as discussed in earlier articles of this series, (*Chem. Eng.*, Apr. 18, 1960, p. 192 and May 16, 1960, p. 156). A discussion of the pertinent equations is also found in *Chem. Eng. Science*, Mar. 1958, pp. 121-123.

The material balance for each reacting component is given by:

$$V(dx/dt) = v(x_i - x) - VR \tag{13}$$

where V is the volume for the reactor, x is the molal concentration of a particular reactant, v is the inlet volumetric flow rate and R is the reaction rate in moles per unit time per unit volume.

An energy balance for the system is represented by the equation:

$$v\rho c(dT/dt) = v\rho c(T_i - T) - VQ - VR\,\Delta H \tag{14}$$

where ρ is density of the reacting mixture, c is specific heat of mixture, T is temperature of mixture, T_i is inlet temperature of the reactants, Q is heat transfer rate from mixture to the coolant and ΔH is heat of reaction per mole reacted.

In general, Q would depend upon the temperature of the mixture and upon the coolant flow rate and temperature. Therefore, Q could be a function of one of the dependent variables T and the independent variable t if the coolant condition is externally controlled.

Reaction rate R would depend upon both the concentration of the reactants and upon the mixture temperature. The dependence of Q and R upon the dependent and independent variables would have to be determined from experimental data or predicted theoretically for each problem. For first order reactions, the general dependence of Q and R may be represented by the algebraic equations:

$$\begin{aligned} R &= R(x, T) \\ Q &= Q(T, t) \end{aligned} \tag{15}$$

If V and v are constant, it is convenient to define a new dimensionless independent variable ϕ such that

$$\phi = vt/V \tag{16}$$

Choosing some constant reference temperature T_o and assuming ρ, c, T_i, x_i and ΔH are constants, we may also simplify the equations by use of the following dimensionless groups:

$$\begin{aligned} \theta &= (T - T_o)/(T_i - T_o) \\ \xi &= x/x_i \\ \psi &= VR/v \\ \alpha &= \Delta H/\rho c(T_i - T_o) \\ \Omega &= VQ/\rho vc(T_i - T_o) \end{aligned} \tag{17}$$

Introduction of the relations given by Eqs. (16) and (17) into Eqs. (14) and (13) yields:

$$d\xi/d\phi = 1 - \xi - \psi \tag{18}$$

$$d\theta/d\phi = 1 - \theta - \Omega + \alpha\psi \tag{19}$$

Eqs. (15) may be rewritten in a similar fashion to give:

$$\begin{aligned} \psi &= \psi(\xi, \theta) \\ \Omega &= \Omega(\theta, \phi) \end{aligned} \tag{20}$$

Since Eqs. (18), (19) and (20) are of the same general form as Eq. (1), the methods discussed in the first part of this article are directly applicable to the numerical solution of this problem. For example, the open approximation given by Eq. (6) could be used to calculate values of ξ and θ at intervals of ϕ using information previously calculated. In the solution of Eqs. (18) to (20), the iteration equations would be:

$$\xi_{k+3} \cong \xi_{k+2} + \frac{\Delta\phi}{12}\,[5F_{1k} - 16F_{1k+1} + 23F_{1k+2}] \tag{21}$$

$$\theta_{k+3} \cong \theta_{k+2} + \frac{\Delta\phi}{12}\,[5F_{2k} + 16F_{2k+1} + 23F_{2k+2}] \tag{22}$$

where

$$F_{1k} = 1 - \xi_k - \psi(\xi_k, \theta_k) \tag{23}$$

$$F_{2k} = 1 - \theta_k - \Omega(\theta_k, \phi_k) + \alpha\xi(\xi_k, \theta_k) \tag{24}$$

Initial conditions for this reactor problem might be specified such that at time zero, the reactor is in a steady-state condition. Such a condition could be specified by the implicit relations

$$\left.\begin{aligned} 1 &= \xi + \psi \\ 1 + \alpha\psi &= \theta + \Omega \end{aligned}\right\} \text{at } \phi = 0 \tag{25}$$

Additional values of ξ and θ necessary to start the iterative process could be determined by Taylor's series expansions about $\phi = 0$ for both dependent variables.

A closed second order approximation involves the solution to the following equations:

$$\xi_{k+2} \cong \xi_{k+1} + \frac{\Delta\phi}{12}\,[5F_{1k+2} + 8F_{1k+1} - F_{1k}] \tag{26}$$

$$\theta_{k+2} \cong \theta_{k+1} + \frac{\Delta\phi}{12}\,[5F_{2k+2} + 8F_{2k+1} - F_{2k}] \tag{27}$$

Eqs. (23), (24), (26) and (27) would have to be solved simultaneously. If the interval size $\Delta\phi$ is small, ψ and Ω will be approximately linear in ξ and θ so that the solution of these equations would not be difficult even though both functions are nonlinear.

Since the calculation of starting values in problems of the type given in this example can be quite laborious, it is often desirable to use approximations which avoid the use of such methods. The only polynomial approximations which do not require starting values are Euler's approximation and the first order closed approximation.

Euler's equation

$$\begin{aligned} \xi_{k+1} &\cong \xi_k + \Delta\phi F_{1k} \\ \theta_{k+1} &\cong \theta_k + \Delta\phi F_{2k} \end{aligned} \tag{28}$$

First-order closed approximation

$$\xi_{k+1} \cong \xi_k + \frac{\Delta\phi}{2}\,[F_{1k} + F_{1k+1}] \tag{29}$$

$$\theta_{k+1} \cong \theta_k + \frac{\Delta\phi}{2}\,[F_{2k} + F_{2k+1}]$$

Coming:

In a forthcoming issue, Dr. Davis will present the concluding article of this five-part series. The final article on unsteady-state heat transfer will cover the numerical solution of partial differential equations by using polynomial approximations.

You extend valve life
in Corrosive and Erosive services
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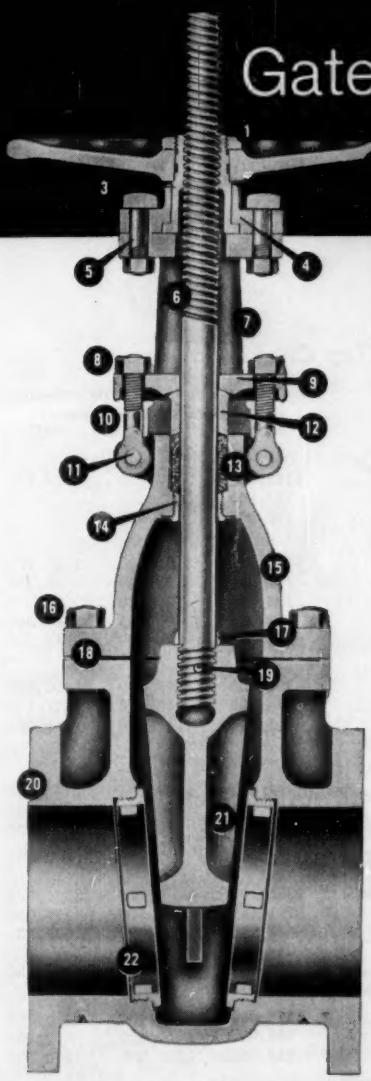

No. 1 ... when you specify "Jenkins" you get not merely "Ni-Resist" metal but you get Type 2 Ni-Resist Cast Iron! That affords extra resistance to acids, salt and alkaline solutions, sea water, brine and other corrosive and erosive fluids, vapors or gases. It is copper-free and will not contaminate or discolor the materials controlled.

Type 316 Stainless Steel is used for the wedge, spindle and other trimmings to give you a combination of metals which have remarkable ability to withstand destructive service.

No. 2 ... you get all the excellence which the Jenkins Diamond trademark has represented for nearly a century. The superior design and construction are visible here. Equally important superiorities which show up only in the records of long service and low maintenance are the close grain and high density of Jenkins castings ... the precision of Jenkins machining ... the rigid inspection and testing which every Diamond-marked valve undergoes.

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1 Bronze yoke bushing nut
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3 Bronze yoke bushing
4 Iron yoke cap with zerk fitting for lubricating bushing
5 Steel yoke cap bolts and nuts
6 TYPE 316 STAINLESS STEEL spindle
7 NI-RESIST CAST IRON, TYPE 2, yoke
8 Bronze eye bolt nuts
9 Malleable iron gland flange
10 Steel gland eye bolts
11 Steel gland lug bolts and nuts
12 TYPE 316 STAINLESS STEEL gland
13 Teflon impregnated asbestos packing
14 TYPE 316 STAINLESS STEEL bonnet bushing
15 NI-RESIST CAST IRON, TYPE 2, bonnet
16 Steel bonnet bolts and nuts
17 TYPE 316 STAINLESS STEEL spindle ring
18 Asbestos gasket
19 TYPE 316 STAINLESS STEEL wedge pin
20 NI-RESIST CAST IRON, TYPE 2, through-port body
21 TYPE 316 STAINLESS STEEL solid I-beam wedge
22 TYPE 316 STAINLESS STEEL seat rings

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Top Pay, Starting Pay and Your Pay

Higher profits in 1959 meant more money for men at the top.
Starting engineering pay is up another 5%.
The problem of salary-range compression worsens.

Total Compensation of Some Top CPI Executives

	Salary Plus Additional Compensation (Does not include stock options.) 1959	1958	1957
ALLIED CHEMICAL CORP.			
Harry S. Ferguson, chmn. ex. comm.	$125,000	$90,000	$82,917
Chester M. Brown, pres.	125,000	.....	.....
Carlton Bates, ex. v.p.	100,000	90,000	.....
CITIES SERVICE CO.			
Burl S. Watson, chmn.	$158,460	$156,720	$154,977
W. Alton Jones, chmn. ex. comm.	131,380	$157,030	155,557
J. E. Warren, pres.	105,791	.....	.....
George H. Hill, Jr., sr. v.p.	83,186	78,905	72,201
Alfred P. Frame, sr. v.p.	83,200	78,920	72,201
COLGATE-PALMOLIVE CO.			
Edward H. Little, chmn. & pres.	$330,000	$297,500	$300,000
Ralph A. Hart, ex. v.p.	174,820	156,294	157,140
George H. Lesch, v.p.	165,000	131,894	115,574
DOW CHEMICAL CO. (Fiscal year May 31)			
Earl W. Bennett, chmn.	$112,871	$119,355	$120,000
Leland I. Doan, pres., chmn. ex. comm.	188,118	198,925	200,000
Mark E. Putnam, ex. v.p.	122,277	129,301	130,000
A. P. Beutel, v.p.	113,742	119,355	.....
E. I. du PONT de NEMOURS & CO.			
Crawford H. Greenewalt, pres., chmn. ex. comm.	$325,100	$296,116	$320,942
Henry B. du Pont, v.p.	221,565	196,500	216,000
Lammot du Pont Copeland, v.p.	235,192	188,400	202,700
Robert L. Hershey, v.p.	214,000	188,200	.....
Robert L. Richards, v.p.	214,000	188,100	211,450
EASTMAN KODAK CO.			
Thomas J. Hargrave, chmn.	$225,000	$210,000	$210,000
Donald McMaster, chmn. ex. comm.	160,000	150,000	150,250
Albert K. Chapman, pres.	225,000	210,000	210,000
GENERAL TIRE & RUBBER CO.			
W. O'Neil, pres. & chmn.	$152,850	$150,850	.....
T. F. O'Neil, v.p.	105,975	95,475	.....
L. A. McQueen, v.p.	105,100	83,875	.....
THE B. F. GOODRICH CO.			
John L. Collyer, chmn.	$125,000	$211,000	$220,000
J. W. Keener, pres.	140,000	149,475	124,167
A. Kelly, ex. v.p.	90,000	180,000	.....
GOODYEAR TIRE & RUBBER CO.			
E. J. Thomas, chmn.	$193,755	$194,320	$187,300
P. E. H. Leroy, v. chmn.	142,636	132,860	130,440
R. De Young, pres.	127,339	117,494	112,604
Victor Holt, Jr., ex. v.p.	76,724	68,600	.....

Table continues on p. 142.

Chemical process industry (CPI) executives were prominent among those leaders of American corporations whose total compensation indicated a prosperous 1959.

Higher profits meant higher pay for the top executives of most companies last year. The accompanying tabulation—based on data assembled by *Business Week*, a McGraw-Hill publication—gives you a selection of top CPI incomes for the years 1959, 1958 and 1957.

"That's interesting," you may say, "but what does this mean to me?"

Well, there is more than curiosity value in publishing this listing each year. Here's why: Most of you are employed by companies that use position evaluation and salary administration plans. There are always two fixed limits on these plans. At the top there's the total compensation of the highest executive responsible for the engineering function. His pay is fixed by the incomes of the top executives of the corporation.

At the bottom, we have the salaries being offered new entrants to the engineering profession.

Since it is not possible to publish the results of a comprehensive salary survey of the entire engineering profession each year, frequent publication of salary ceilings and floors does serve a useful purpose for the entire profession.

▶ **'59 Was a Good Year** — Although, as a general rule, higher

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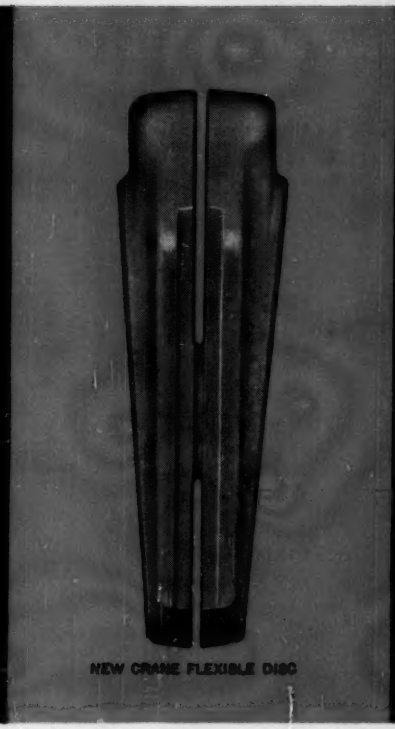
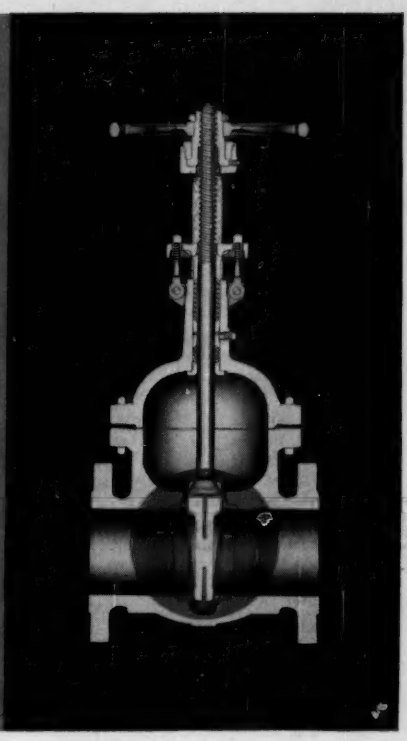
. . . a fast-moving program of planned expansion, product development, and streamlined distribution to help our customers meet the challenge of the Soaring Sixties.



NEW CRANE FLEXIBLE DISC



The most significant advance in gate valve design in 25 years...

CRANE FLEX GATES®

Instead of being made with a solid disc, new, patented Crane Flex Gates have separate disc faces, connected by the axle-like unit shown in the cross section. This joins the two seating faces, yet provides flexibility for the faces to seat tightly with independent action.

BECAUSE THEY'RE FLEXIBLE, new Crane Flex Gates seat with less torque.

BECAUSE THEY'RE FLEXIBLE, new Crane Flex Gates unseat with less torque . . . will not stick closed even when closed while hot and allowed to cool.

BECAUSE THEY'RE FLEXIBLE, minor deflection of seating faces due to pipe strains does not affect tightness of Crane Flex Gates.

BECAUSE THEY'RE FLEXIBLE, new Crane Flex Gates are tight on inlet seat and outlet seat over a wide range of pressures.

BECAUSE THEY'RE FLEXIBLE, new Crane Flex Gates can be used singly in some services where two conventional gate valves are frequently specified. You can save substantially on piping costs.

BECAUSE THEY'RE FLEXIBLE, new Crane Flex Gates can be serviced—body seat rings replaced or seating faces refinished—quickly, and without painstaking accuracy. Slightly off-taper seats do not affect tightness or operating ease.

BECAUSE THEY'RE FLEXIBLE, new Crane Flex Gates will easily outperform any conventional solid wedge disc valve you now use. *And there's no increase in price.*

BECAUSE THEY'RE MADE BY CRANE, these new Flex Gates are completely dependable. You can use them with complete confidence on steam, water, gas, oil or oil vapor service. Stem and disc seating faces are Crane Exelloy. Shoulder-type body seat rings are Exelloy or Crane No. 49 Nickel Alloy. Sizes: 12 inch and smaller; 150- and 300-pound pressure classes.

Ask your Crane Distributor for full information on Flex Gates—and for data whenever you work with the products Crane makes. He has the newest in information and products. Crane Co., Industrial Products Group, 4100 South Kedzie Avenue, Chicago 32, Illinois.

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Compensation of Some Top CPI Executives, continued

	Salary Plus Additional Compensation (Does not include stock options.) 1959	1958	1957
GULF OIL CO.			
David Proctor, chmn.	$93,750	$185,116	$218,858
R. O. Rhodes, ex. v.p. & chmn.	225,028	181,719	137,526
W. K. Whiteford, pres.	323,006	303,110	317,548
MERCK & CO., INC.			
Vannevar Bush, chmn.	$25,000	$30,200	.....
John T. Connor, pres.	135,300	131,310	$115,777
Henry W. Gadsden, ex. v.p.	129,861	123,650	108,465
MONSANTO CHEMICAL CO.			
C. A. Thomas, pres., chmn. ex. comm.	$162,000	$135,000	$137,500
Carroll A. Hochwalt, v.p.	108,000	90,000	93,750
William W. Schneider, v.p.	108,000	90,000	93,750
Felix N. Williams, v.p.	108,000	90,000	93,750
OLIN MATHIESON CHEMICAL CORP.			
Thomas S. Nichols, chmn.	$135,000	$125,000	.....
John M. Olin, chmn, ex. comm.	135,000	125,000	.....
Stanley De J. Osborne, pres.	135,000	118,333	.....
Edward Block, sr. v.p.	91,667	75,000	.....
CHAS. PFIZER & CO., INC.			
John E. McKeen, chmn. & pres.	$249,583	$249,408	$200,875
John J. Powers, Jr., sr v.p.	169,131	168,407	160,512
Allan J. Greene, admin., v.p.	93,475	95,139	98,478
PHILLIPS PETROLEUM CO.			
K. S. Adams, chmn.	$200,000	$200,000	$200,000
Stanley Learned, chmn. ex. comm.	150,500	135,000	135,000
Paul Endacott, pres.	160,000	145,000	145,000
W. W. Keeler, ex. v.p.	125,000	105,200	105,000
Rayburn L. Foster, v.p.	85,000	85,200	85,000
PROCTER & GAMBLE CO. (Fiscal year June 30)			
Richard R. Deupree, chmn.	$100,000	$100,000	$100,000
Howard J. Morgens, pres.	327,007	281,683	233,324
Walter L. Lingle, Jr., ex. v.p.	264,607	257,359	233,324
SHELL OIL CO.			
H. S. M. Burns, pres. & chmn. ex. comm.	$247,500	$220,000	$200,000
Monroe E. Spaght, ex. v.p.	148,500	148,500	125,000
R. C. McCurdy, pres. Shell Chemical	137,500	137,500	115,000
STANDARD OIL CO. OF CALIFORNIA			
R. G. Follis, chmn.	$212,619	$213,877	$201,604
T. S. Peterson, pres.	186,018	187,118	174,327
Gage Lund, v.p.	127,509	128,265	119,797
STANDARD OIL CO. (Indiana)			
Frank O. Prior, chmn.	$180,230	$177,935	$169,734
John E. Swearingen, pres.	136,475	123,124	101,067
Robert C. Gunness, ex. v.p.	112,113	.....	.....
STANDARD OIL CO. (New Jersey)			
Eugene Holman, chmn.	$273,775	$273,775	$276,854
M. J. Rathbone, pres.	234,587	219,025	221,389
E. E. Soubry, ex. v.p.	168,137	.....	.....
Leo D. Welch, ex. v.p.	157,188	.....	.....
TEXACO, INC.			
Augustus C. Long, chmn.	$224,550	$203,086	$221,250
J. W. Foley, pres.	131,322	135,391	129,820
C. B. Barrett, sr. v.p.	77,232	82,743	.....
UNION CARBIDE CORP.			
Morse G. Dial, chmn.	$300,000	$300,000	$300,000
Howard S. Bunn, pres.	200,000	177,083	175,000
Kenneth H. Hannan, ex. v.p.	113,667	101,000	100,083

profits and higher income for the top man went together, there were some exceptions.

Standard Oil Co. of California translated lower 1959 profits into pay cuts that extended below the level of top executives. On the other hand, Gulf Oil Corp. raised its compensation despite a lower net.

In most companies, though, profit and compensation figures both reflected a prosperous 1959. Typical were: Aluminum Co. of America, du Pont, Eastman Kodak, General Foods Corp., Monsanto Chemical Co., Procter & Gamble Co., Standard Oil Co. (Indiana), Standard Oil Co. (New Jersey) and Union Carbide Corp.

▶ **Floor Raised 5%**—At the bottom, a United Press International survey disclosed last month that the nation's 1960 engineering and scientific graduates are worth 5% more in starting pay to competing industry and government than they were one year ago.

Here's a letter that *CE* received from one 1960 graduate in chemical engineering:

"I have compiled some data on the current salaries being offered the five-year graduates here. You had expressed an interest in the job situation when I visited you in New York last February.

"Jobs are plentiful! Everyone has two or three offers and those who really pushed have up to ten. In straight engineering work (i.e., process design, research & development, production), the average going rate is about $550/month.

"As usual, the first few men are attracting offers of $575/month and more if they have accumulated valuable summer experience. In the sales-oriented jobs the spread is somewhat wider, ranging from $525 to $575/month.

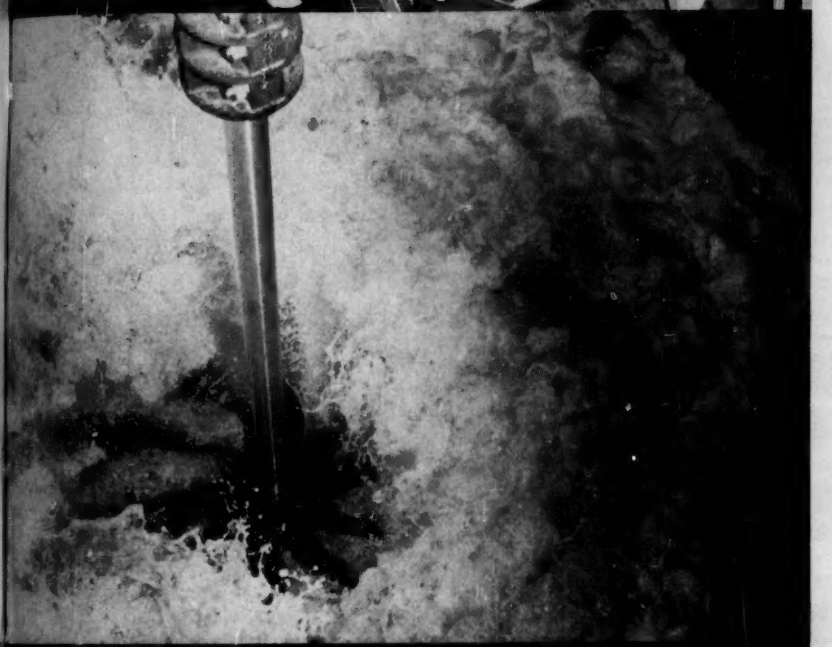
"Very roughly, about 25% of the class will be going on to graduate schools (not all in engineering); about 25% into the military services; and 50% will be going to work. Most of those going to work will be taking jobs with the 'big name' companies. There is no favorite industry, though the rubber industry seems rather left out of the picture.

"You could be of considerable help to me in making my own job decision. At your suggestion I went to see the five companies you named. Each has now made me an offer and if you could find a moment to squeeze out a few lines of advice, commentary or scuttlebutt, I would be most appreciative."

▶ **In the Middle**—So much for the ceiling and the floor, what's happening to the middle levels of the salary structure?

There is one recently released set of data that may shed some

AT *fmc* . . . NINE YEARS OF COMPLETE MIXING WITH MINIMUM MAINTENANCE!



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3. A complete mix is the result of Nettco Engineered Agitation in large tanks of hot phosphate solutions.

4. Soda ash dissolving in hot water . . . one of many Nettco mixing applications at FMC.

13 Nettco Mixers in Constant Service—and only two bearing replacements in *nine years*. This is NETTCO's performance record at the Newark, California plant of the Mineral Products Division of Food Machinery and Chemical Corporation.

Downtime Can Be Expensive—a breakdown can tie up an entire production line. In FMC production lines—atop large tanks of boiling liquids . . . subject to extremely heavy starting loads—operating in high humidity atmospheres—durable NETTCO mixers provide consistently balanced mixes with minimum maintenance.

At FMC, Nettco Mixers are used for: agitating, mixing, reacting, suspending solids, blending miscible liquids, circulating, heat transfer and continuous treating. The results: Complete mixes, close product control and minimum downtime.

For Dependable Mixing—more profit in your process—contact your nearest Nettco representative. See Chemical Engineering Catalog or Refinery Catalog for address . . . or write for Bulletin 581.

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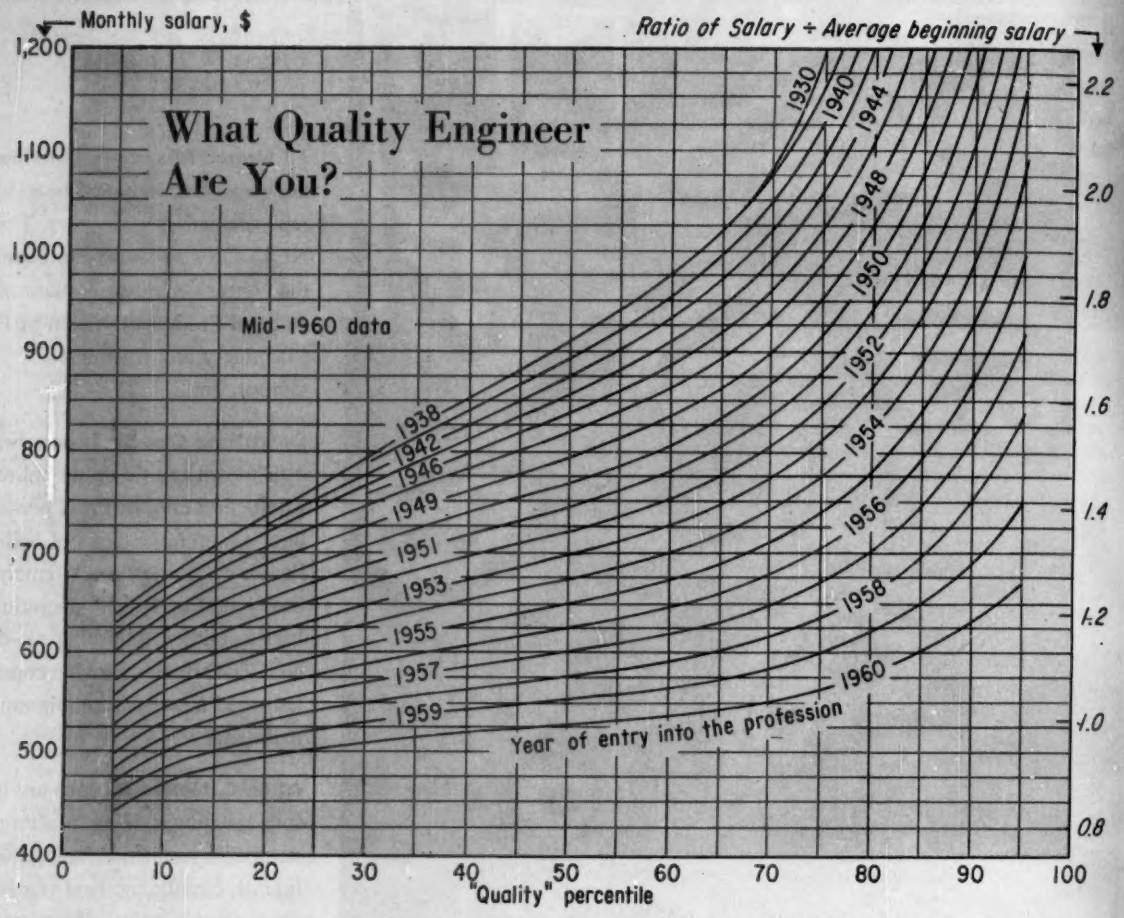


SALARY EXPRESSES QUALITY. Based on Mid-1960 data, this union-originated plot suggests that you progress along a "constant-quality" salary parameter. **RIGHT-SIDE ORDINATE** scale relates your pay to salaries offered to new graduates. Market price has risen steadily for the past 20 years.

light on middle-level engineering salaries in mid-1960. However, some may possibly object to the source of this information. Nevertheless, reproduction of the diagram above will probably do more good than harm even if the source may be distasteful to a few. That is why we have decided to reprint it.

[The source is Engineers & Scientists of America (ESA), an affiliation of engineering unions which—until it lost the Western Electric election on May 10, 1960—claimed to represent 30,000 professionals.]

According to ESA, "These curves have been prepared to represent the engineering profession plus those mathematicians and physical scientists working with the engineering profession, in the entire United States in the middle of 1960. They have been prepared to permit an engineer to determine what 'quality' is indicated by his present salary, or by a salary offer.

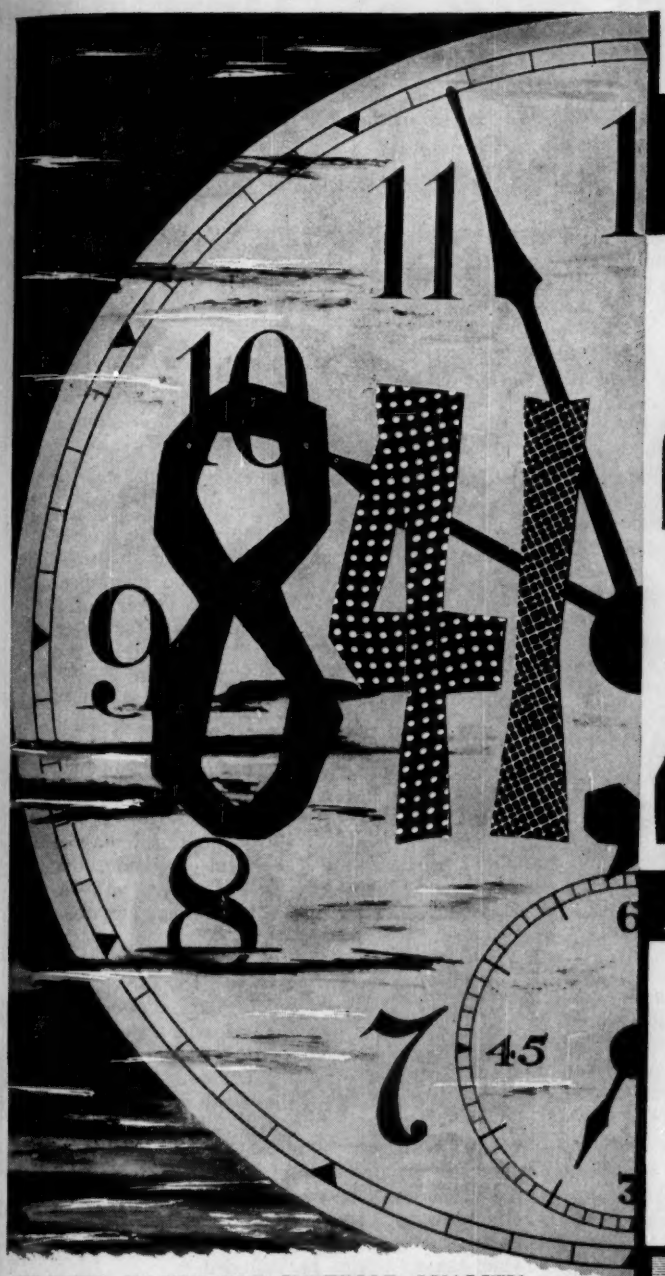
▶ **Why Use Quality?**—"A distinguishing characteristic of the salary structure of the engineering profession is *spread*.

"Not only do salaries tend to increase with experience, they are very much higher for more able engineers than they are for less able engineers. For this reason, ESA has chosen to plot salary data using 'quality' as the abscissa."

Naturally, there are many pros & cons to plotting salary data in this fashion. *CE* has discussed this matter with the president of the largest single ESA union and with the executive secretary of Engineers Joint Council and we are familiar with both sides of the argument.

Our publication of this type of plot and of these data is without editorial comment, except to say this: The chart was deliberately planned by its creators to cause unrest about engineering salaries and to give the impression that they are too low. Is this a case where the end may justify the means?

We'll be interested in your comments.



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FOR EVERY PURPOSE.

PROVED IN USE FOR SUPERIOR QUALITY, DEPENDABILITY AND SAFETY . . .

Whether you count the hours, the days, or the years, world-wide industry has counted on NORWALK as the reliable source of compressors that fulfill every specification: from single stage to six stages; from 125 to 42,000 PSI pressure; for a full range of gases: Acetylene, Air, Argon, Specific Hydro Carbons, CO and CO_2, Ethane, Ethylene, HCL, Helium, Hydrogen, Nitrogen, Nitrous Oxide, Oxygen.

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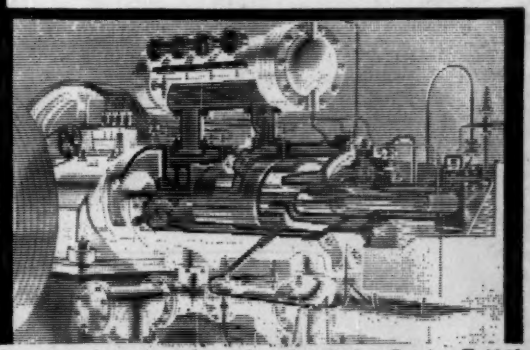


Write, wire, phone for informative, descriptive Catalog F-1960

NORWALK COMPANY, INC., SOUTH NORWALK, CONNECTICUT

COMPRESSOR SPECIALISTS TO WORLD-WIDE INDUSTRY SINCE 1864

CE COST FILE

No. 35: Estimating Pressure Vessels

A. J. REILLY, Scientific Design Co., New York, N. Y.

Rapid Estimating for Pressure Vessels

Curves and tables in this Cost File, based on May, 1960, costs, can be used for rapid cost estimating of tanks, columns and other pressure vessels.

To prepare the estimate, vessel is broken down into major components, each of which has a cost assigned in the graphs and tables, and the cost of each component enters the total cost.

Sequence of Data

The basic curve, shown on the next page, is arranged to show cost of a carbon steel (A-285-C) ASME Code vessel shell with two flanged and dished heads. Shell and head thickness ranges from ¼ to 1 in. Shell diameters vary from 3 to 12 ft., and shell lengths are 20-100 ft. (Curves of this basic graph can be extrapolated enough to widen this length range to 0-120 ft.)

Costs are determined for the basic vessel by starting at the tangent length, moving up to reference line, across to shell thickness, up (or down) to correct diameter curve and then horizontally across to the vertical cost axis to read cost in hundreds of dollars.

Cost on the vertical axis doesn't include nozzles, trays, skirts or other components. To obtain cost for basic vessel made of 304 or 316 stainless steel, multiply cost for the carbon steel vessel of same specifications by the factors shown in the table on the graph. (Factors for 120-ft. tangent length are: 304, 4.7; 316, 6.0.)

Add Nozzles and Manholes

To the basic vessel cost, as found above, must be added the cost of nozzles and manholes. We have selected an average nozzle cost for tanks and columns, differentiating between those vessels greater than, and less than, 4-ft. dia. Average count of these items for columns and tanks is shown below.

Average Count For Columns	Size
3	1/3 shell diameter, not to exceed 12 in.
3	1/4 shell diameter, not to exceed 10 in.
10	1 1/2-in. dia.
4	2-in. dia.
2	18-in. manholes (for columns over 4-ft. dia.)
2	12-in. handholes (for columns under 4-ft. dia.)
For Tanks	
2	1/3 shell diameter, not to exceed 10 in.
1	1/4 shell diameter, not to exceed 8 in.
2	1 1/2-in. dia.
2	2-in. dia.
1	18-in. manhole (for tanks over 4-ft. dia.)
1	12-in. handhole (for tanks under 4-ft. dia.)

Average Nozzle Cost

	150 Lb.			300 Lb.		
	Carbon Steel	304 SS	316 SS	Carbon Steel	304 SS	316 SS
Tanks						
Above 4 ft.	$900	$1,100	$1,450	$1,300	$1,700	$1,900
Under 4 ft.	700	850	1,050	950	1,200	1,450
Columns						
Above 4 ft.	2,200	2,800	3,100	2,900	3,800	4,600
Under 4 ft.	1,700	2,300	2,500	2,100	2,900	3,400
Manways						
18-in.	500	600	700	750	950	1,100
24-in.	800	1,100	1,150	1,250	1,550	1,800

Add Column Internals

Total estimated costs, as outlined so far, are sufficient for estimating the cost of a simple vessel without internals—the sum of shell and heads plus the cost of nozzles and manholes.

If the vessel, however, is a tray tower, refer to the graph of tray costs vs. diameter on p. 150. Here can be found the cost/tray for bubble-cap trays from 18-in. to 144-in. diameter constructed of carbon steel, 304 stainless or 316 stainless.

Unit costs on this graph include tray supporting ring and shop installation. Supporting rings are approximately one-half the cost of stiffener rings, as shown on the second graph of p. 150. A tray thickness of ⅜ in. was used for carbon steel to 48-in. dia. and ⅛-in. thickness for stainless steel. Caps are on 3-in. centers; 3-in. caps and 2-in. downcomers were assumed.

For sieve trays, use 40% of bubble tray cost.

No allowance has yet been made for cost of the column skirt. Referring to unit cost for skirts on the curve of p. 150, add a skirt corresponding in thickness to the column shell. These cost units were calculated for a 6-ft. length of carbon steel shell with a bolting ring and base plate.

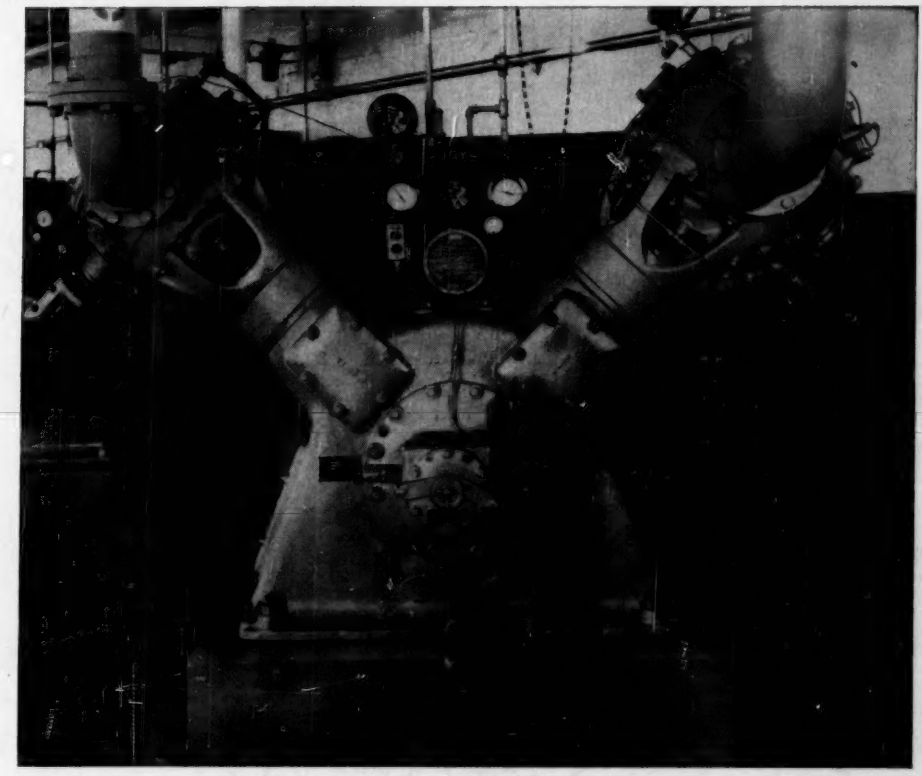
Unit costs for column stiffening rings appear on the same graph. Although no attempt has been made to evaluate an optimum shell thickness by use of stiffening rings, for estimating purposes one ring for every 5 ft. of shell length might be included.

Final additive cost for columns is that of assembly and testing, shown in the last graph of p. 150. In this category are included bolts and gaskets, spot x-ray, paint and testing, ASME inspection, skid and load for shipment. Stress relieving, not included, would range from $300-500 according to size of vessel.

Let Us Hear From You

Send your cost data, preferably in tabular or graphical form and with a minimum of text, to CE Cost File Editor, Chemical Engineering, 330 W. 42nd St., New York 36, N. Y. Any legible form is acceptable. We will pay regular department space rates for all the material published in Cost File.

MAINTENANCE-FREE JOY COMPRESSORS PROVIDE LOW COST PLANT AND PROCESS AIR



The cost of your plant and process air depends both upon the installed cost of the compressor and the cost of maintenance necessary to keep it operating. Joy compressors offer savings in both areas.

Installed cost of Joy compressors is lower because of the space-saving design. However, the big savings are realized in the low maintenance required for Joy compressors—particularly in the oil-free types. For example, the compressor above has the exclusive T-block design piston rings that last twice as long by automatically compensating for wear. As for valves, which normally require inspection and maintenance, Joy designers have made them readily accessible and secured by only three well-positioned bolts.

Joy reciprocating compressors are available in a wide range of sizes for both oil-free and plant air service. For complete information on how Joy compressors can save you money on air, write for Bulletin 849-11.

AIR MOVING EQUIPMENT FOR ALL INDUSTRY

JOY

Joy Manufacturing Company
Oliver Building, Pittsburgh 22, Pa.

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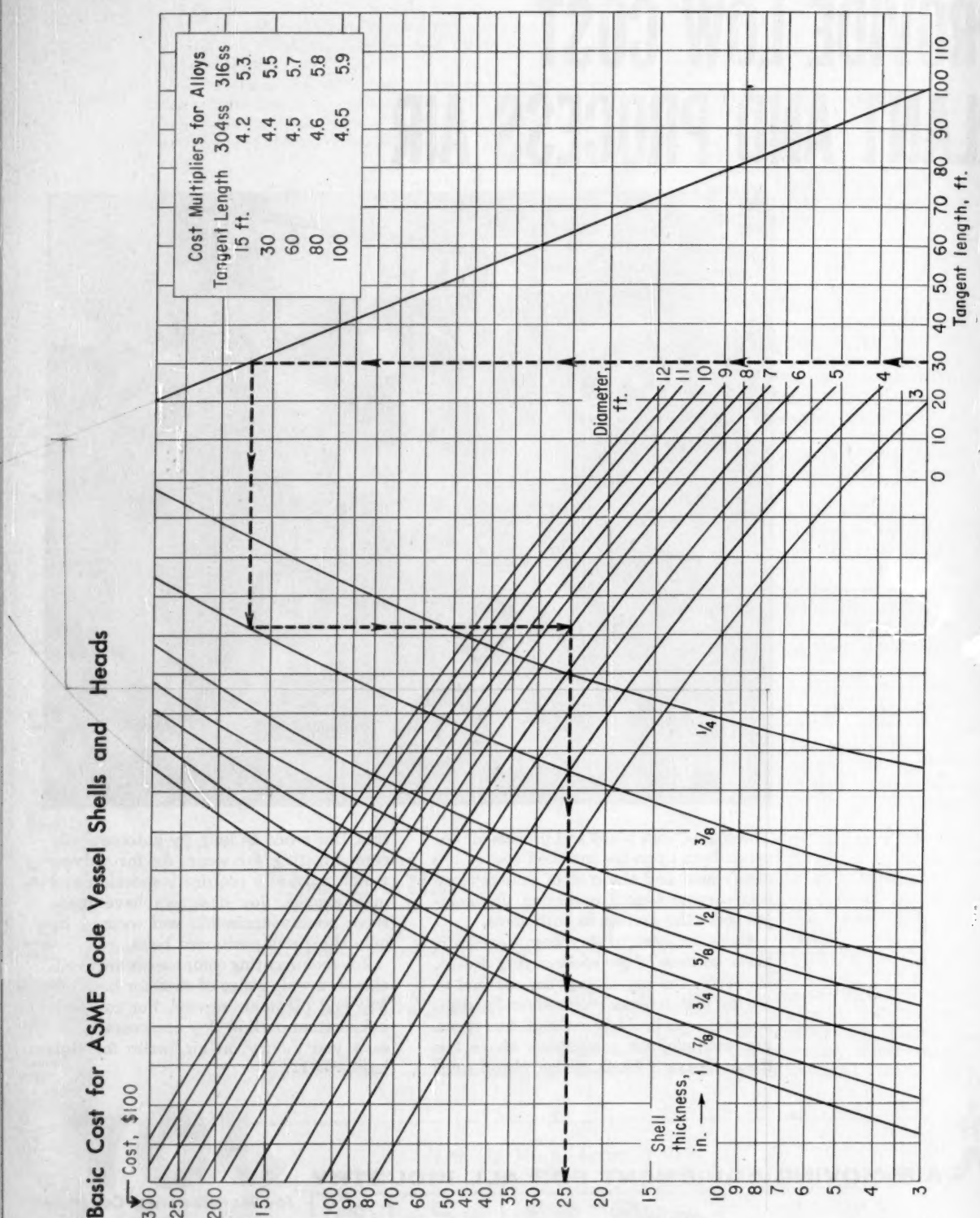
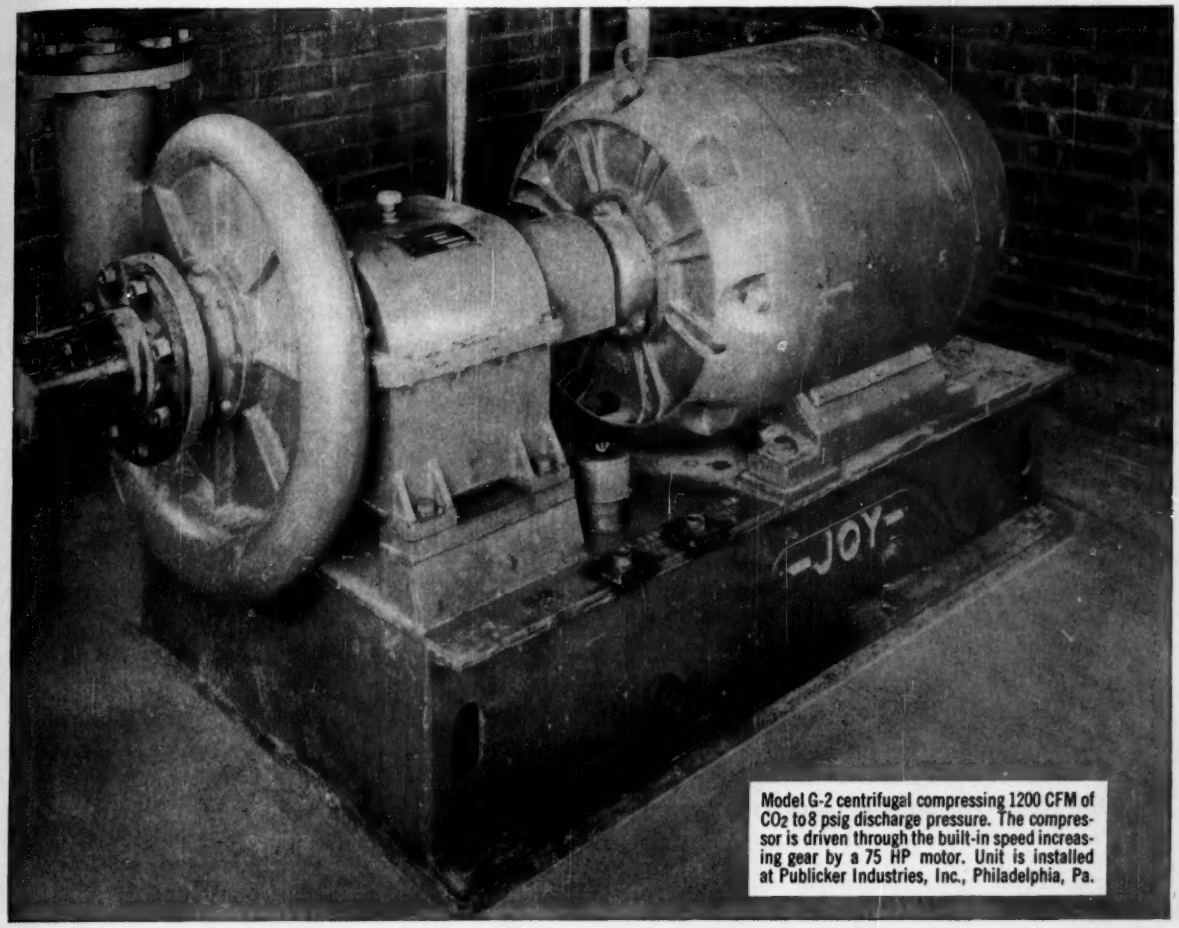

Basic Cost for ASME Code Vessel Shells and Heads
Cost, $100
300
250
200
150
100
90
80
70
60
50
45
40
35
30
25
20
15
10
9
8
7
6
5
4
3
Shell thickness, in. → 1
7/8
3/4
5/8
1/2
3/8
1/4
Diameter, ft.
12
11
10
9
8
7
6
5
4
3
0 10 20 30 40 50 60 70 80 90 100 110
Tangent length, ft.
Cost Multipliers for Alloys
Tangent Length 304ss 316ss
15 ft. 4.2 5.3
30 4.4 5.5
60 4.5 5.7
80 4.6 5.8
100 4.65 5.9

COMPACT AND EFFICIENT



Model G-2 centrifugal compressing 1200 CFM of CO_2 to 8 psig discharge pressure. The compressor is driven through the built-in speed increasing gear by a 75 HP motor. Unit is installed at Publicker Industries, Inc., Philadelphia, Pa.

JOY CENTRIFUGAL COMPRESSORS TAKE LESS THAN HALF THE SPACE

Joy Centrifugal Compressors are efficient and compact. Superior performance is the result of designs using advanced aerodynamic concepts and space-age metallurgy. The impeller is machined from a single alloy-steel or aluminum forging and keyed to an alloy steel shaft which is integral with the speed increasing gear. For compactness, the compressor casing is bolted to the gear casing.

The result of this design is trouble-free service with remarkable savings in maintenance . . . the maximum of compressed air or gas for the power consumed and floor space occupied.

Joy Dynamic Compressors are available in both centrifugal and axial designs, with a capacity range from 15 to 15000 HP. For complete details on how Joy Centrifugal and Axial Compressors can save space and money on your compression requirements, write for bulletin 1491-11.

AIR MOVING EQUIPMENT FOR ALL INDUSTRY

JOY

Joy Manufacturing Company
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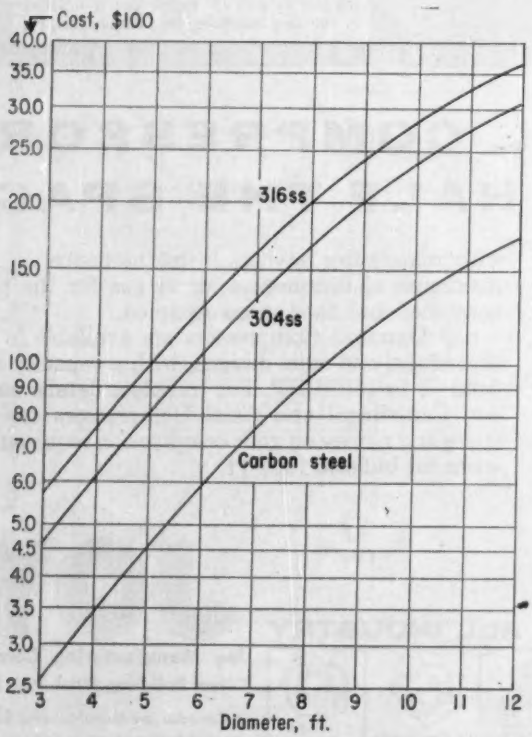
Try an Example

With the addition of assembly and testing costs, the total column is now complete. All costs are based on competitive rather than conservative pricing range. Individual shop practices can vary these costs by some 15%.

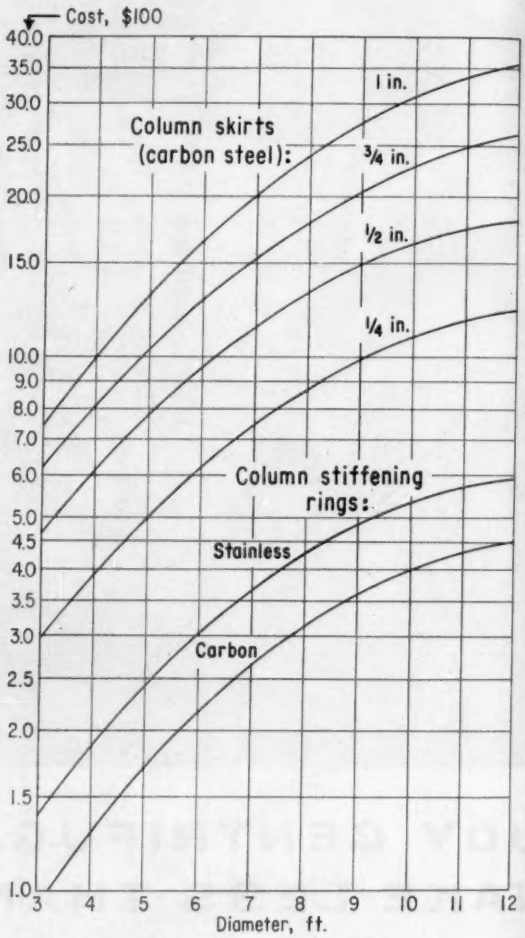
A bubble-cap tray column, 7-ft. dia., 30 ft. high, with ⅜-in. shell thickness, is basically estimated on the curve of p. 148 by the dotted lines. Assuming 316 stainless steel construction, 18 trays and two 24-in. manways, the following costs can be calculated:

From graph of p. 148:	
Shell and heads, $2,500 × 5.5	$13,750
From nozzle tables:	
150 psi. ss, $3,100	
Deduct 18-in. manway included in average nozzle cost @ $700	
Add 24-in. manways, $2,300	4,700
From tray cost graph:	
18 trays, 7-ft. dia.	28,800
From vessel component graph:	
Add vessel skirt, 7-ft. dia.	
Interpolated cost for ⅜-in.	950
Allow for six 7-ft. rings @ $370	2,220
From assembly & testing curve:	
Add, for 7-ft. dia.	1,800
Total cost	$52,220

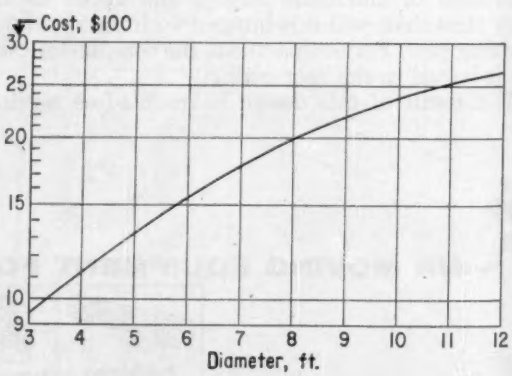
Unit Cost of Bubble-Cap Trays



Unit Cost of Vessel Components



Column Assembly and Testing



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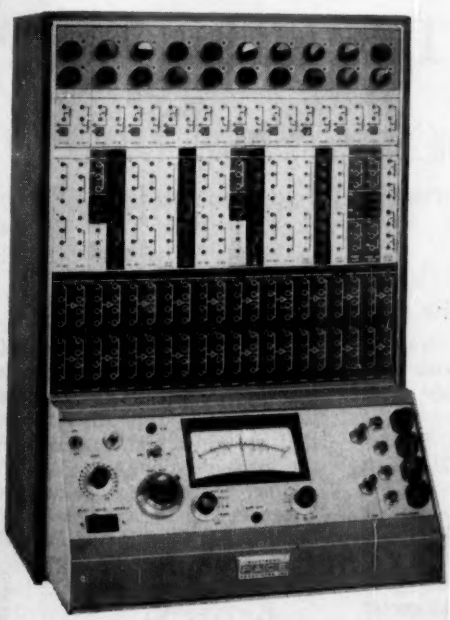
PACE® TR-10, the first all transistorized desktop analog computer, puts proven high-speed computation right where it's needed – on the desks of busy engineers. With this easy-to-use simulator, you can quickly solve many problems without waiting for scheduled access to large-computing systems. Though compact in size, the TR-10 is a full-fledged analog computer capable of providing solutions to a wide range of design problems. Up to 20 amplifiers, plus linear and non-linear computing components are contained in one compact cabinet with no external racks. The TR-10 permits rapid evaluation of different design approaches. It demonstrates the performance of a conceptual or drawing-board design prior to construction. Thus it saves time and money normally required for multiple test models with cut-and-try engineering.



Here's How The TR-10 Saves Engineering Time

The TR-10 is especially useful in solving problems in such diverse areas as servo-system design, heat flow, chemical reaction analyses, suspension systems studies and many other problems involving dynamic conditions. Fast answers to problems posed by new design ideas immediately determine feasibility of projects. With the TR-10, engineers can explore new ideas as they occur – concentrate valuable time on the most promising area of study.

(Applications notes are available describing typical problem solutions.)

How Do You Use The TR-10?

First—Represent in equation form the physical system to be studied.

Second—Select through a simple computer diagram the computing components required to perform the calculation (programming).

Third—Interconnect these components on the computer (problem patching) and set problem parameters with adjustable controls.

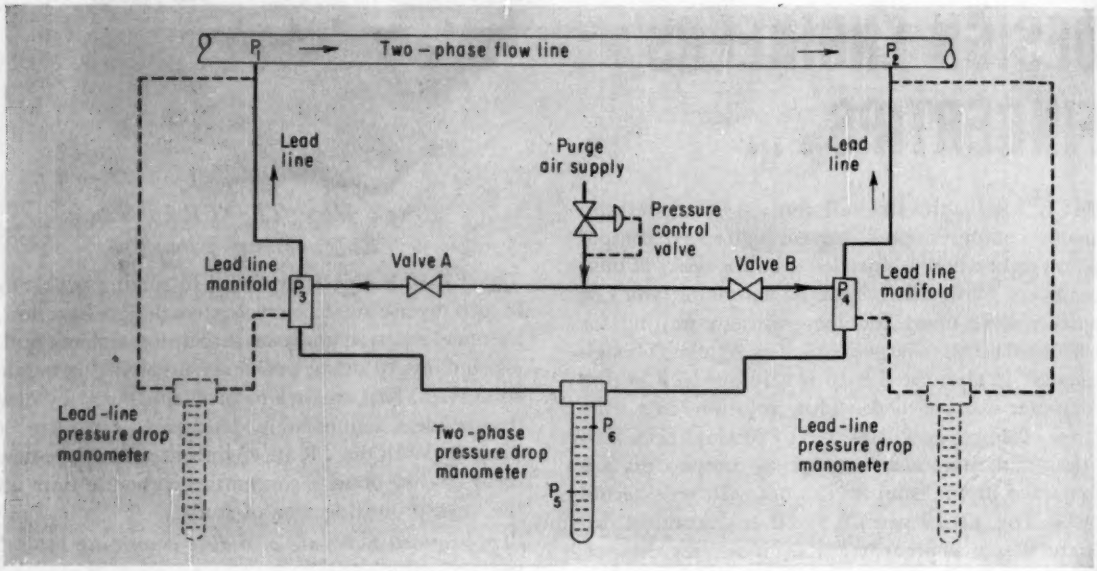
Fourth—Run the problem with results presented graphically on an accessory recorder or oscilloscope.

You now have an electronic analog *model* of the physical system under study. You can manipulate design parameters quickly, running comparative solutions without becoming involved in repeated calculations. With the TR-10 you can rapidly develop truly optimum designs.

For complete details of TR-10, write for free copy of Bulletin AC 934-EB.

PACE TR-10 Analog Computer, including components for addition, subtraction, multiplication, division, integration and generation of powers, roots, logs, antilogs and arbitrary functions.

EAI ELECTRONIC ASSOCIATES, INC. *Long Branch, New Jersey*



Better Way to Measure Two-Phase Flow

Here is a way to eliminate uncertainties in measuring differentials in two-phase systems, as encountered in metering liquid-gas and solid-gas.

Moye Wicks III

Teaching Fellow, Department of Chemical & Petroleum Engineering, University of Houston, Houston, Tex.

Differential-pressure-reading instruments such as U-tube manometers are commonly used in measuring flow. However, in attempting to apply this method to multi-phase flow (e.g., boilers, condensers, furnace transfer lines, fluidized beds, and the like), the problem arises of maintaining only one of the two phases in the connecting or lead lines. Experiments have shown that mixed phases or plugs in these lines can lead to serious errors in the measured differential pressure.

One way to bring about a single-phase condition in the lead lines to the manometer is to purge them continuously with one of the flowing phases of the system. In the diagram, for example, the purge fluid is shown as air which is bled into the two lead lines through valves A and B.

However, using such a purge brings up the question, "Can purging affect the manometer reading?" Under certain circumstances the answer is "Yes." Our problem is to find how to avoid this undesirable effect. As the following analysis will show, this can be accomplished as in the diagram by adding the manometers shown dotted, and adjusting the purge-air flows so that the added manometers show the same readings.

Since there is no net flow between P_3 and P_5, and between P_4 and P_6, then $P_3 = P_5$ and $P_4 = P_6$. Then:

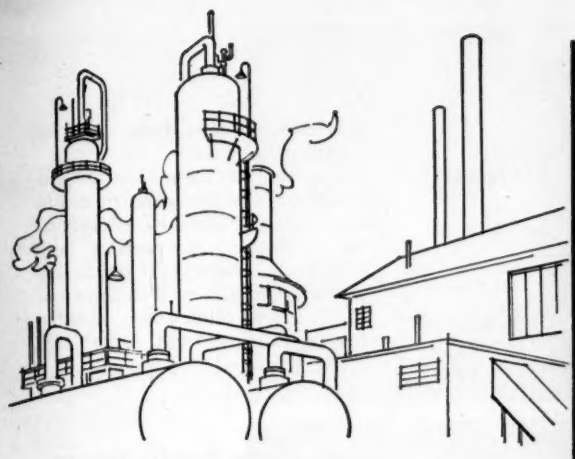
$$P_1 = P_5 + \Delta P_{1-3} \quad (1)$$

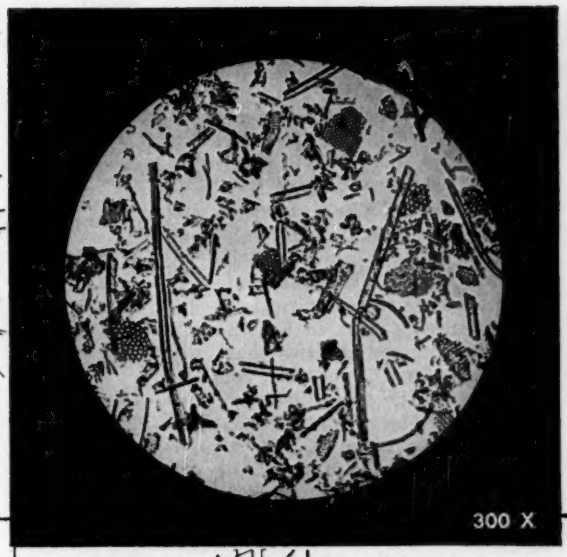
$$P_2 = P_6 + \Delta P_{2-4} \quad (2)$$

Subtracting Eq. (2) from Eq. (1),

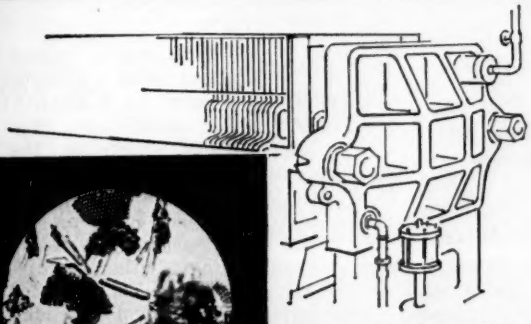
$$P_1 - P_2 = P_5 - P_6 + (\Delta P_{1-3} - \Delta P_{2-4}) \quad (3)$$

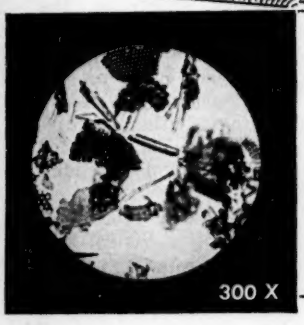
Eq. (3) shows that $P_1 - P_2$, the



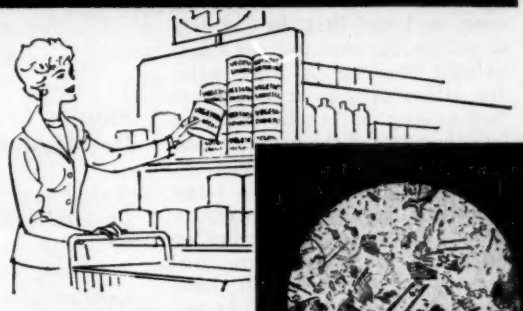


For flow rate plus clarity—Hyflo Super-Cel has the right combination of large and fine particles. Heavily used in chemical processes such as caustic soda production.

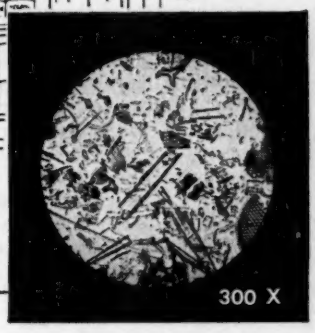




For fast flow rates—Celite 545 has a higher proportion of coarse particles. Frequently used for clarification of resins and other viscous liquids.



For maximum clarity—Filter-Cel has a relatively fine particle size distribution. Used in producing lard, salad oil, other hydrogenated oil products.



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Celite has the exact grade for every filtration need from fast flow rate to maximum clarity

Study samples of various filtration grades of Celite* diatomite with the unaided eye. Rub them between your fingers. One grade looks, feels very much like another.

Then compare these grades under the microscope. Each has its own distinctive particle size distribution. Each is precision-milled to fill the most exacting filtration requirements, ranging all the way from maximum flow rate to maximum clarity.

Celite 545, for example, with a higher proportion of large to fine particles, is used to remove large suspended impurities at maximum flow rates. *Hyflo Super-Cel®* has a balanced particle size distribution, combines good liquid clarity and moderate flow rate. But *Filter-Cel®* has a much higher ratio of small particles, is tailored for use where high clarity outweighs flow rate.

Whatever your filtration problem—Johns-Manville can furnish the "right" grade for the job. You have a choice of 9 intermediate grades *plus* many special grades. Each comes from the largest and purest commercially available deposit. Each is processed and graded at the same plant under the same uniform conditions.

For information on specific filtration or mineral filler problems, talk to your nearby Celite engineer, or write to us. Johns-Manville, Box 14, N. Y. 16, N. Y. In Canada, Port Credit, Ont.

*Celite is Johns-Manville's registered trademark for its diatomaceous silica products

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two-phase differential, can equal $P_3 - P_4$ as shown by the manometer only when the term in parenthesis in Eq. (3) equals zero, i.e., when $\Delta P_{1-3} = \Delta P_{2-4}$.

Thus, by installing manometers across points 1 and 3, and 2 and 4, and by adjusting the valves A and B so that these manometers have the same reading, the parenthesis term in Eq. (3) will drop out and the two-phase manometer will show the correct ΔP for the two-phase flow.

This technique was checked by comparing measured and calculated pressure drops across the test section for the single-phase flow of air. In all cases the agreement was excellent. Moreover, we found that the quantity of purge gas used had no measureable effect on the differential for either single- or two-phase flow as long as its total flow was less than 1% of the gas flow rate through the test section.

The diagram shows a setup involving frictional pressure drop only, without an orifice or other differential pressure producer. An orifice could have been used equally well except that, interestingly enough, it seems not generally to be needed in two-phase flow systems where very large differentials are obtained without an orifice. In our test installation we used a 1-in. copper water tube with pressure taps 12 ft. apart. With two-phase flow we obtained the following differentials:

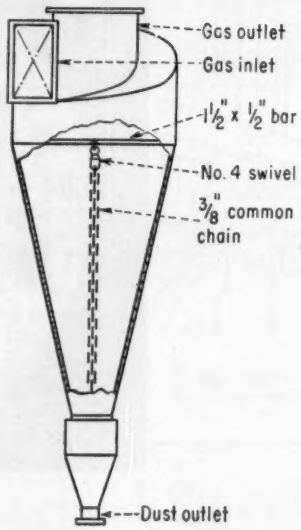
Flow, Lb./Hr.		ΔP, In.
Liquid	Gas	
521	126	8.15 No. 3 oil*
3,126	491	20.2 Hg

* Oil sp. gr. 2.95

These data for horizontal two-phase flow are large compared with the frictional pressure drops normally obtained with single-phase flow. For example, with the separate phases in the same setup, using the No. 3 oil in the manometer for *all* tests:

Liquid	
Lb./Hr.	ΔP, In. Oil
521	0.0687
3,126	1.73
Gas	
Lb./Hr.	ΔP, In. Oil
126	1.72
491	20.9

It is obvious, therefore, that friction can be much more significant in multiphase than in single-phase systems.



Simple Chain Scraper for Dry Dust Collectors

A. J. Stewart
Chemical Construction Corp.
New York, N. Y.

Sketched above is a simple way of preventing hygroscopic dust such as urea and triple-super from sticking to the inclined walls of cyclone-type dust collectors.

The idea is to support a length of chain, which is about 2 in. longer than the vertical height of the hopper sides, directly on the center line of the collector. This is easily accomplished by welding a flat bar inside the collector just above the bend line. The chain hangs from this by means of a swivel.

In its vortexing action the gas stream moves the scraping chain rapidly along the inclined side of the collector, preventing any dust from adhering. If the action is too noisy a 2- or 3-in. layer of fiberglass or other sound absorbing insulation will cure this difficulty.

Emergency Repair for an Oleum Outlet Valve

John X. F. Smith
Chemical Engineer
Pittsburgh, Pa.

We recently solved a rather ticklish problem when a bottom-outlet gate valve in a 500-gal. batch tank containing 20% oleum became stuck in the closed position. In attempting to open the valve we snapped off one of the hooks engaging the rising stem. Our problem was to replace the valve without emptying the tank, since facilities for emptying it were not readily available.

We found a rather simple solution by driving a conical lead plug into the open outlet pipe in the tank bottom. The plug was rigidly attached to one end of a piece of 1-in. pipe. Since there was little head-room over the tank, the pipe had to be made up of several shorter pieces joined together as the pipe was lowered by means of couplings.

Next Issue: Watch for Winner of June Contest

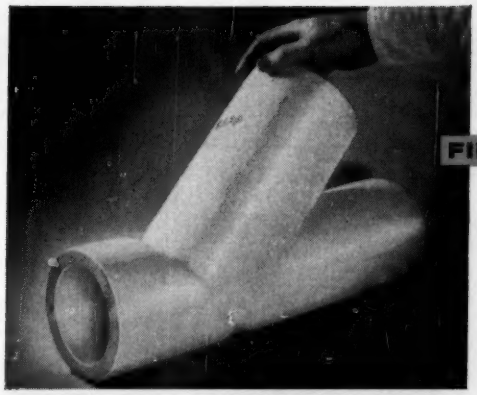
★ How Readers Can Win

$50 Prize for a Good Idea—Until further notice the Editors of *Chemical Engineering* will award $50 each four weeks to the author of the best short article received during that period and accepted for Plant or Process Design Notebooks. Each period's winner will be announced in the second following issue and published in the third or fourth following issue.

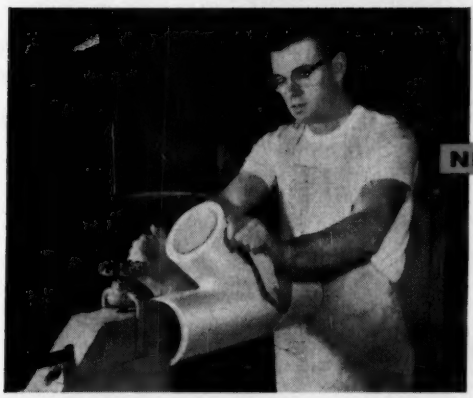
$100 Annual Prize—At the end of each year the period winners will be rejudged and the year's best awarded an additional $100 prize.

How to Enter Contest—Any reader (except a McGraw-Hill employee) may submit as many contest entries as he wishes. Acceptable material must be previously unpublished and should be short, preferably not over 500 words, but illustrated if possible. Acceptable nonwinning articles will be published at space rates ($10 minimum).

Articles should interest chemical engineers in development, design or production. They may deal with useful methods, data, calculations. Address Plant & Process Design Notebooks, *Chemical Engineering*, 330 W. 42 St., New York 36, N. Y.



FIRST . . . the valve itself—Lapp porcelain, chemically inert, to resist corrosion from any acid (except Hydrofluoric) in a process.



NEXT . . . layers of strong Fiberglass cloth to cushion the porcelain against impact and insulate it against thermal shock.

AND THEN, high-strength, chemical-resistant Epoxy resin, impregnating the Fiberglass, bonding it to the porcelain—adding the protection of armor to the corrosion resistance of Lapp chemical porcelain.

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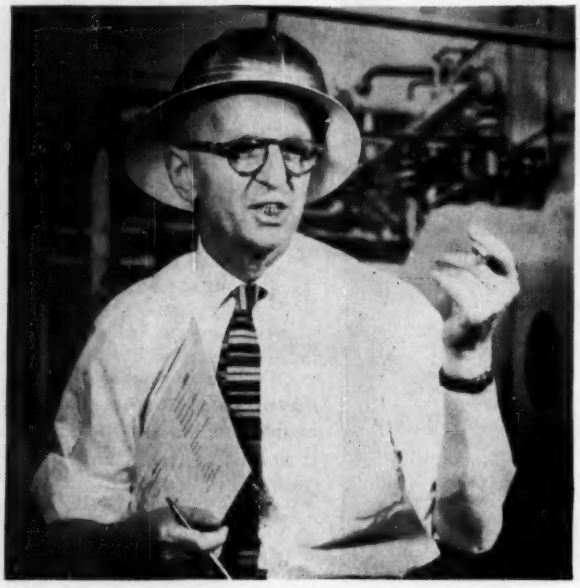
Lapp
CHEMICAL PORCELAIN

WRITE *for Catalog 567—description and specifications of Lapp Y-Valves and Angle Valves, available in ½" to 6" sizes. Lapp Insulator Co., Inc., Process Equipment Division, 1907 Chestnut St., LeRoy, N. Y.*



Be Practical About Safety

Elaborate programs, squads of experts have a place, but safety ultimately depends on the individual.

Wingate H. Richardson, Consultant, New York, N. Y.

I came across a little item in the paper the other day concerning the accidental death of an explosives manufacturer's representative. He was demonstrating the safe and proper way to use explosives when the accident happened.

Several years ago an inspector from the Department of Safety of one of our large cities was inspecting a large public dining room. He wanted to be sure that certain decorations were fireproof so he tested them with a match. They weren't.

▶**Those That Can . . .**—I have had some first hand experience of a similar nature which fortunately was not so tragic.

We had established a safety department in one of our plants. One of the first projects they came up with was a safety instruction program about which the operating departments were not too happy. They felt that safety was an operating problem which they were handling quite well and thought that a separate instruction course would cause trouble. Nevertheless, they set up the program and brought an expert in from Chicago to train our employees in safe practices. He opened his first session with a discussion of the proper methods for handling heavy drums and concluded with a demonstration—the safe way to pick up a drum with a hand cart.

He broke his arm on the first try.

Since most of our trainees had been doing this day in and day out for a number of years without breaking any arms, they became rather skeptical about the value of the instruction.

▶**Safety Is Operating Problem**—If you are beginning to suspect that I am opposed to safety departments or to safety instructions, let me assure you that I am not. These episodes are the exceptions.

Yet we cannot help speculating on the possible reasons for accidents to safety personnel engaged in demonstrating their specialty. Perhaps their total preoccupation with the theory and practice of safety, per se, makes it impossible for them to become skilled in the operations to which their safety measures must be applied.

It is for this reason that I am firmly convinced that the total responsibility for safety, and the authority for discharging that responsibility, should rest with the operating department. The safety department increases in value in proportion to its ability to see itself as a service organization and in proportion to the operating department's ability to see the value of the service offered. The more the safety department sees itself as a police agency, or the more the operating departments ignore its advice, the less its value becomes.

The same safety department that brought in the expert from Chicago also instituted a system of safety inspection, which was all to the good. However, we had a relatively new plant and all equipment was in first class condition. The operators were well trained and there wasn't too much to report from their safety inspections. They did come up with one item periodically that bothered them.

THE *NEW* ROOTS 3000 cfh GAS METER IS "JUST A BULGE IN THE LINE!"

*Size 3M125 1/2 actual size

Gas men who've previewed it are mighty excited about the cost saving features of the new Roots-Connersville 3000 cfh rotary gas meter. Only 14" long, a workman can pick it up with one hand and carry it under his arm.

Because it incorporates the famous Roots rotary positive displacement principle, accuracy is permanently locked in for the long, trouble-free life of the unit. Actuated by the gas flow itself, twin rotors displace a fixed volume of gas with each revolution, unaffected by variations in pressure or flow. Extremely close clearances between rotors assure accuracy while eliminating all friction and need for internal lubrication. Occasional replenishing of oil is the only maintenance required under normal operating conditions.

Here, is *the* efficient and economical way to meter industrial, commercial and institutional gas loads. Call in your Roots-Connersville sales engineer or write for complete data.

- **Replaces meters several times its size and weight**
- **Only 14" long—mounts in the line**
- **A bare 53 pounds**
- **Accurate to 3000 cfh and up to 125 psi**
- **Easily installed**
- **Direct reading or can be instrumented**
- **Quickly tested on standard equipment**
- **Virtually eliminates maintenance**
- **Requires no special supports**

ROOTS-CONNERSVILLE BLOWER DIVISION
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ROOTS
first in air and gas handling equipment

DRESSER INDUSTRIES, INC.
OIL • GAS • CHEMICAL • ELECTRONIC • INDUSTRIAL

I had set up a special procedure for handling welding operations in the process area which required one man to be on the job with a fire extinguisher and with no other duty than to be available if needed. He usually took the nearest available fire extinguisher. After completion of the job he sometimes failed to return it to its proper station.

One day the inspector came in to tell me he had solved the problem. He was quite pleased. He took me out to the nearest extinguisher and pointed out the results of his effort.

"Now let's see your operators take these extinguishers off their hooks."

He had carefully wired every extinguisher to the wall with a short length of steel cable!

▶**Safety Inspectors Are Needed**—An over-zealous safety inspector can cause a lot of trouble, but none can be worse.

At one plant the safety committee consisted of six or eight senior operators with little or no formal organization. The committee operated on a rather haphazard basis, meeting at infrequent intervals and about once every four months they performed a rather casual plant inspection.

So one day we had a fire. The fire alarm system was connected into an annunciator board in the boiler house. When a fire signal came in, a flag dropped showing the location of the fire and the fireman blew the fire call on the steam whistle. But this time the flag on the board did not drop and when the volunteers arrived at the boiler house, no one knew where the fire was. Eventually a runner from the scene of the fire arrived with the information and our fire department took off at high speed with the hose cart.

In the best tradition, they wrapped the end of the hose around the fire hydrant nearest the building and the hose unreeled at a merry clip as they went on to the building. But alas! The hose had recently been used to wash out a process tank and had been replaced on the reel backwards so that we had two male fittings at the hydrant.

This was hurriedly remedied by a lot of hand jockeying. But then they discovered that the nozzle was missing, so a runner had to be sent to the tank farm to find it.

Meanwhile, back at the ranch, the operator had been fighting a grim battle against the fire with the garden hose used for scrubbing down the floor and had succeeded in putting out the fire. Nearly exhausted, choking with smoke, he went to the door of the building in time to be met by a stream of water from the three-inch fire hose that bowled him over.

▶**Make Regular Inspections**—Failure of the fire alarm system could have been avoided with a regular procedure for inspection and testing of the system. This was of course done after the fire and it was found that at least six flags were inoperative.

The problem with the fire hose and nozzle would also have been picked up with a proper inspection system but even the best system would not have caught it immediately. In this case, the basic error was the use of the fire hose for a production operation

It is simple enough to establish safety rules prohibiting the use of the fire hose for such purposes, but in a small plant it is not so easy to assure compliance. Every operating man knows that emergencies will arise during which temporary use of the fire hose is mandatory, or at least appears to be. One solution is to provide equivalent equipment for emergency use by operating personnel. But even this is not fool proof.

Without some type of safety organization with specific responsibility for such items, the servicing of fire protection equipment after use is often overlooked.

On one occasion we had a small fire which was extinguished with CO_2 hand units. The next morning I checked to see that they had been returned for refilling. They had not been returned and no one seemed to know how this was done or who was responsible for it.

We got that straightened out quickly enough, but then I became concerned about the condition of the rest of the units. So I went down to the plant and

People Still Saw Off the Limb

One day one of our maintenance men, Pop Kelly, was brought into the office with a badly injured leg. Pop was over sixty and had been with us a long time. He was not careless, yet in a thoughtless moment an accident had happened. On the way to the hospital I asked Pop how it happened.

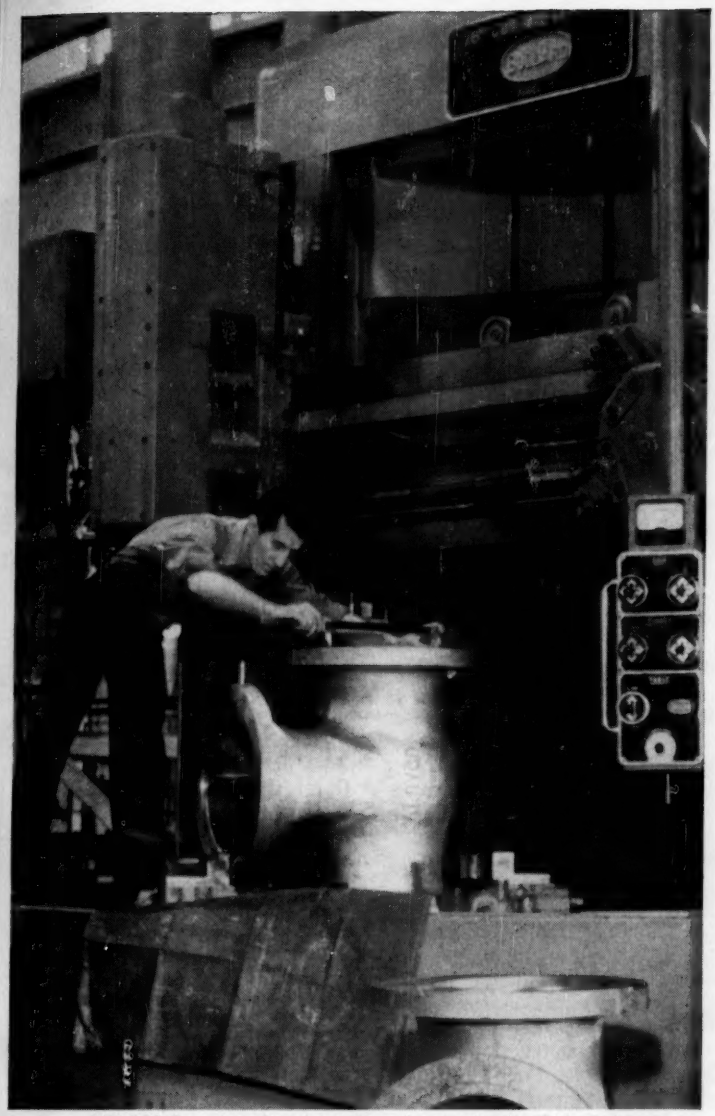
"Well," he said, "I'm kind of ashamed to tell you. I feel like the man who sawed the limb off behind him."

"Some of the boys were taking down a partition in the storage shed. They had it all down except for a 4x4 that was wedged between the two side walls. They had thrown a rope over it and were pulling on the rope, but they couldn't get it loose. I got impatient and said 'Here, I'll get it down'."

"So I put a ladder up, picked up a sledge, climbed to the top of the ladder and knocked it loose with one blow. It wasn't till then that I remembered that the only thing holding that ladder up was the 4x4. So the 4x4, the ladder, the sledge and I all came down together."

That is one of the principal causes of accidents, a moment's thoughtlessness. From the safety angle, the significant thing is that six or seven men watched without one of them thinking.

Had the plant had any program of safety training certainly at least one of these men would have been aware of the danger.



14" 300 lb. gate valve slated for a large petro-chemical plant, is being worked on one of Aloyco's battery of new Bullards.

Advanced machines... tools...test facilities expand Aloyco Valves' range of service

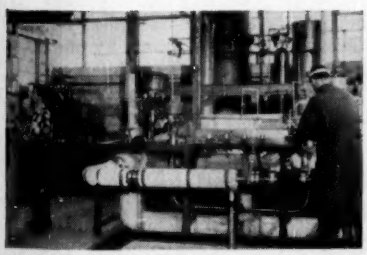
Constant change and improved techniques in modern fluid handling, pose a real challenge for valve manufacturers.

To meet these demands, Aloyco is constantly adding new facilities, some of which are pictured here.

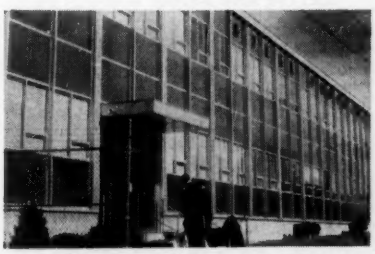
For example, Aloyco Stainless Steel Valves are now available in sizes up to 24", pressures up to 2,500 lbs. at 650°F.

While these new facilities have improved and expanded the quality and usefulness of our entire line, they are particularly important, for example, in the manufacture of valves for the nuclear and missile fields.

For advanced knowledge and ideas plus the equipment to carry them out—take your next valve problem to the specialists: Alloy Steel Products Company, 1301 West Elizabeth Avenue, Linden, New Jersey. o.e



One of finest hot test loops in the nation checks out valves at up to 2500 psi, 650°F. Hot tests can spot trouble that would otherwise be revealed only after months of line service.



New multimillion dollar Aloyco plant combines new production tools, test facilities, sales, administration, research and development offices and labs into single integrated unit.

Boroscope examination (in pressurized clean room) of specially made nuclear valves follows the application of dye penetrant.

ALLOY STEEL PRODUCTS COMPANY

LINDEN, NEW JERSEY

Boston • New York • Wilmington • Atlanta • Birmingham • Baton Rouge • Buffalo
Pittsburgh • Chicago • St. Louis • San Francisco • Los Angeles • Seattle

had the foreman weigh each unit. None contained a full charge and some were completely empty.

It is reasonably common knowledge that CO_2 extinguishers are good for cooling beverages. During the hot months they sometimes lose their charge during the night shift.

▶**Small Plants Need Safety, Too**—Lack of a satisfactory safety department is of course most common in a small plant. The majority of larger plants are usually well staffed with full-time safety personnel. But even the smallest operation should have at least one individual with direct responsibility for safety matters and a well organized program for the promotion of safe operating practices.

With a satisfactory safety organization, your safety record will then depend on constant alertness of operating personnel.

If you make a trip through any plant with the single purpose of spotting unsafe conditions or practices, you will be surprised at how many you find. Look for trouble before trouble looks for you. Do this often enough and soon you will have developed the habit so that it becomes a subconscious part of your operating technique.

▶**The Human Element**—Our vacuum evaporators were fed from a battery of four stainless steel tanks. One night, due to an interruption in an earlier stage that caused a feed liquor shortage, the evaporator operator opened the valves to all four tanks to keep running as long as possible.

"Suddenly," he said later, "those tanks started to shrink. I couldn't believe it. But when the first tank buckled in at the side, I realized what was happening and shut off the valves to the other tanks."

We lost two tanks beyond repair and we had some maintenance work to get the others back in service. What happened?

We had been having some trouble with dirt in the product and one of our young engineers thought he had the answer. He thought it was due to fly ash from the boilers getting into the vent pipe which extended up through the roof from the feed tanks. So he had stuffed rags into the vent pipes to stop the fly ash.

When you get a bright idea, be sure you check for safety before you try it out.

One of our operations involved a vapor phase reaction carried out in a reactor equipped with an explosion vent containing a rupture disk. It didn't happen very often, but once in a while these disks blew, but except for some wear and tear on the nerves, we never had any damage.

During one of our periodic shutdowns for repair and maintenance, the rupture disk was removed for inspection. It was in excellent condition. It had been carefully installed between the two sheet steel plates used to protect it during shipment! How did it happen? A new, very capable and self reliant operator had a disk blow during the night shift. So he had replaced it with the new "assembly."

▶**Jokers Aren't Funny**—One of the most annoying hazards met with in plant operations is the practical joker. I have known some top operators who have suffered from this malady which can be fatal.

If a man cannot break himself of the habit, he should be separated from your organization at the earliest possible moment.

▶**Build In Safety**—Always check new construction for safety, if possible, during initial design, planning and construction phases, but definitely before you start operations. Design engineers are very thorough in considering the safety aspects of a design. They are principally interested in the technical aspects of safety, such as safety valves, explosion vents, relieving capacity of vent lines and proper instrument action to assure safe shutdown.

But it has been my experience that somewhat less attention is paid to what might be called architectural features such as clear exit ways, fire doors, emergency exits and such minor but annoying and sometimes as dangerous details as protruding pipes, valve handles and other obstructions at head and floor level. Perhaps the nature of this type of hazard makes it inherently difficult to foresee.

When new facilities are installed at an existing plant where available area is at a premium, these items can become a major source of trouble.

At one of our plants a new facility was under construction when I noticed that one room containing a number of tanks had no outside exit. The only windows were high above the tops of the tanks well out of reach. The only exit from this area was through the operating area and in case of fire in the operating area, anyone in the storage room would be trapped.

Could I persuade the design department to correct this situation? I could not. Their final argument was "Most of the time there will be no one in there. We do not consider a fire exit necessary under these circumstances."

Fortunately, this construction was subject to inspection by the local fire department and they withheld a permit to operate until a proper exit was installed.

▶**Don't Get Complacent**—Some time ago I visited an explosives plant. At the entrance to the plant, a large billboard announced that the plant had completed 215 days without a lost-time accident. During my visit I commented on this and offered my compliments. To my surprise, the production manager was pretty glum about it.

"I wish they wouldn't give so much publicity to our safety record," he said, "the boys get too complacent. Every day I make a point of reminding them that every time that number out there goes up by one, the number of days until our next lost time accident goes down by one."

Safety is a serious business. The price of security is constant alertness to possible hazards.

Previous Articles In This Series

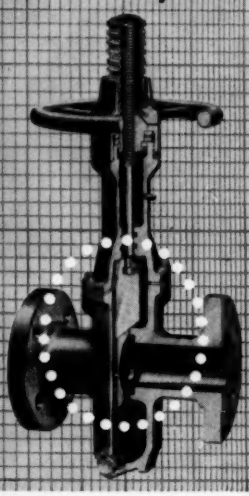
Sept. 21—
Temperature Control

Nov. 30—
Inventory Cheating

Feb. 8—
Specifications

May. 2—
Salesmen

PRODUCT OF W-K-M's
Creative Engineering



FLOATING SEATS MAKE THE SEAL

Seats are specially formulated rubber molded to a hardened steel insert. They float against the gate. When the gate closes, line pressure forces the gate against the downstream seat making a tight seal. The upstream seat maintains its seal against the gate for an upstream seal. The valve provides a tight seal under little or even no line pressure or under vacuum conditions.

W-K-M's new Pressure Sealing Gate Valve

Almost without effort . . . you get a tight seal on *both* sides of the line. The secret? A unique seat design that puts line pressure to work *for* you. The greater the pressure, the tighter the seal!

Seats automatically adjust for wear . . . automatically relieve excessive body pressure. And on-the-line overhaul is easy.

Specify W-K-M's economical new Pressure Sealing Gate Valve for pressures to 720 psi (cwp) and temperatures to 250° F. Sizes 2″ through 30″. *At leading supply stores everywhere.*

WRITE FOR CATALOG 1200

W-K-M

DIVISION OF ACF INDUSTRIES
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P. O. BOX 2117, HOUSTON, TEXAS

5925

Evaluating Wear-Resistant Materials

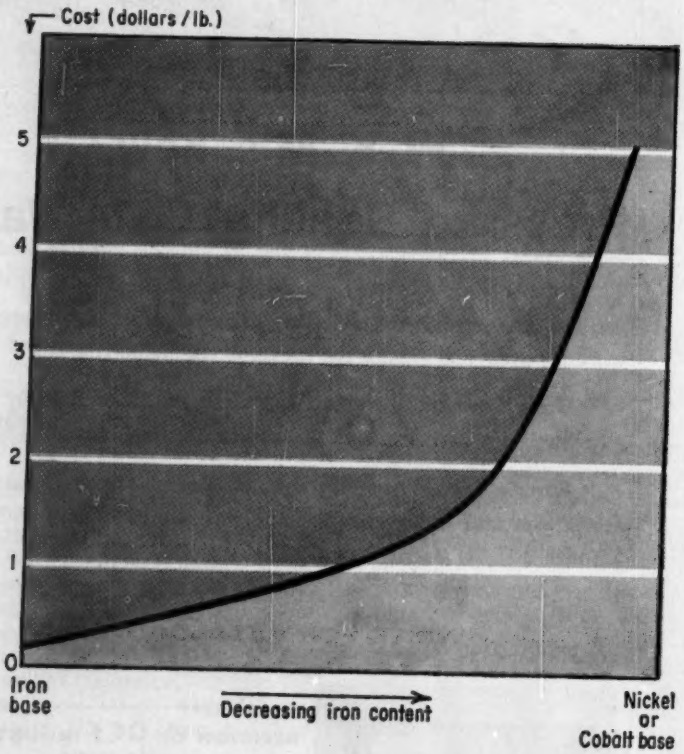
An alloy with very high wear resistance will usually be brittle or have poor mechanical properties. Here is help in making wise compromises.

Wear, as well as corrosion, is an ever-present problem in chemical plants.

But choosing the best wear-resistant material is not as easy as it sounds. First there is a large variety of materials on the market, each with particular mechanical, metallurgical properties and costs (*see curve*). And second, how do you define "best"? A material with excellent wear properties may be very brittle.

R. P. Culbertson of Haynes Stellite, in a talk given at the third annual ASME National Maintenance and Plant Engineering Conference, sheds some light on this dark corner of the materials field. He sees eight major material groupings:

Costs Rise Sharply for Highly Alloyed Wear Materials



► **Wear Materials** — Austenitic manganese steels are widely used as wear-resistant materials. They have good impact strength and fair abrasion resistance. But poor corrosion resistance, poor machining properties and brittleness when heated above 600 F., limit applications.

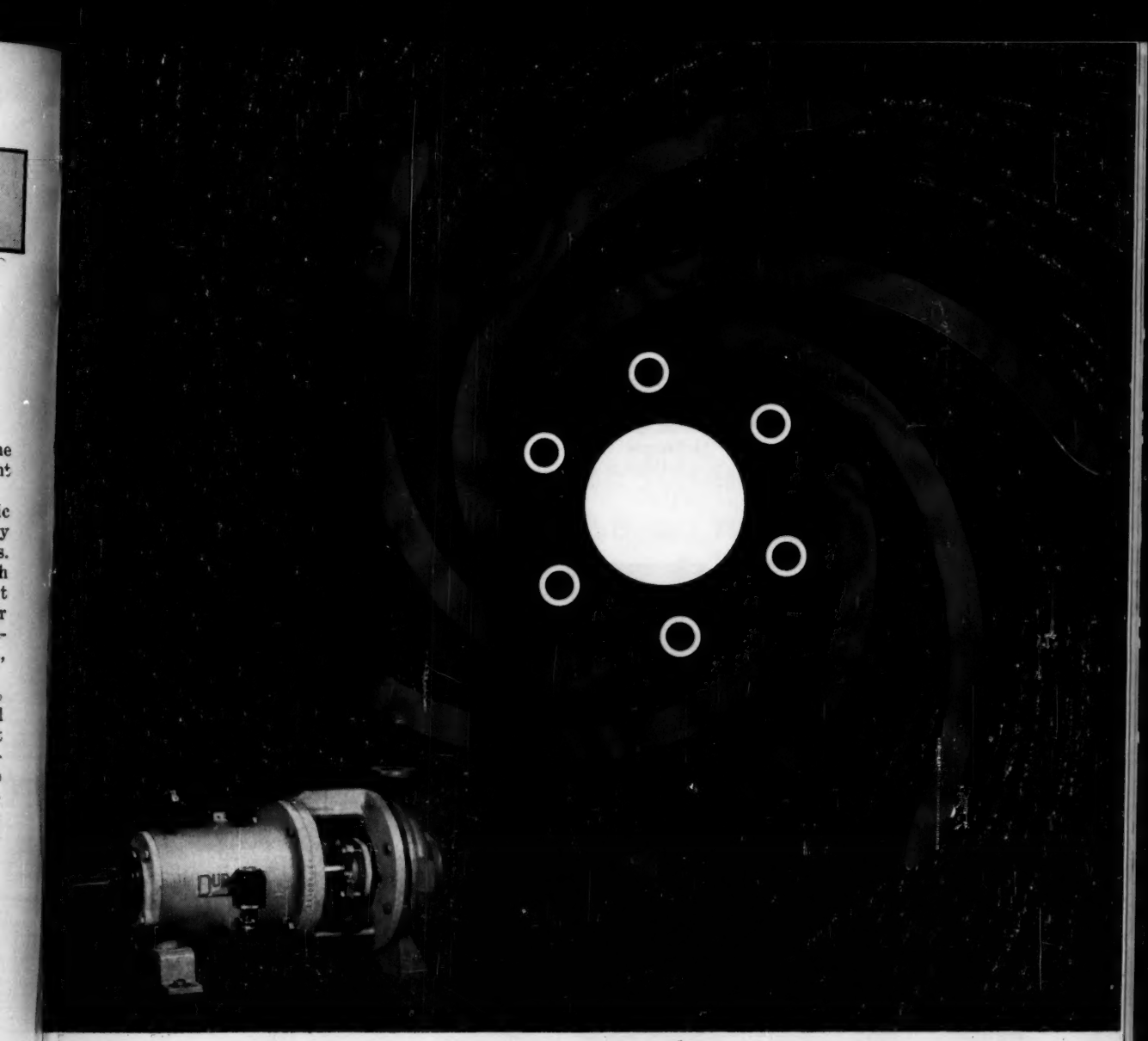
Pearlitic steels, 0.75 to 0.90% carbon, are used for general build-up and repair, but do not significantly improve wear resistance. These materials are used when a part has to be repaired to its original shape, but when wear is not a severe problem.

Martensitic steels are probably the most widely used wear-resistant materials. They contain from 5 to 9% Cr, 0.6 to 1.1% Mo and about 0.7% C. Such steels have excellent cold abrasion resistance with somewhat reduced impact strength. They are easy to apply and relatively cheap.

High-chrome irons (27% Cr, 2.75% C) are excellent for cold abrasion and retain some abrasion resistance to 1,000 F. Because of the high chromium content, such irons have very good oxidation and corrosion resistance. Impact strength, though, is rather low, and they should not be used where this property is important.

► **Ni Alloys** — The nickel-base alloys (60% Ni, 15% Cr, 16% Mo) provide good hot strength, work hardening and abrasion properties. They have excellent service life in applications calling for toughness and abrasion resistance.

Nickel-base cast alloys with high silicon and carbon contents offer the advantage of low melting point (1,850 F.) for easy



Specific design for pumping corrosives

Here is the first pump designed specifically for long life in heavy duty corrosive service.

Durcopumps are made in fourteen standard alloys and special materials. Four bearing housings plus separate frame adapters give maximum interchangeability for all pump sizes.

Maintenance is short and sweet because the working parts can be removed as a unit—in minutes—serviced and reinstalled by a single trade. Pump casing, piping and motor are not disturbed.

Durcopumps are produced in standard, self-priming and vertical submerged designs. Pumps are available with heads to 345 ft., capacities to 3500 gpm, in sizes from 1″ x 1″ to 10″ x 8″. Standard operating temperatures to 500° F.

Call your nearest Durco Service Engineer or write for literature on your service application.

DURCO

CORROSION RESISTING ALLOYS & EQUIPMENT

THE DURIRON COMPANY, INC., Dayton, Ohio / Pumps • Valves • Filters • Process Equipment

How Tough Are Hard-Facing Materials?

(Order of Decreasing Impact Strength)

Austenitic manganese steel
Pearlitic steel
Martensitic steel
Nickel-base (wrought)
High-chrome iron
Cobalt-base
Nickel-base (cast)
Tungsten carbide

application. They are usually applied by powder-spray techniques. Nickel cast alloys have good hardness and abrasion resistance, but galling resistance is not as good as cobalt-based alloys.

Cobalt-based materials are known for excellent hot strength and hot hardness, and are used extensively at high temperatures. They resist corrosion and oxidation at temperatures up to 1,800 F.

For the ultimate in abrasion resistance, tungsten carbide is perhaps the best choice. However, tungsten carbide deposits have low impact strengths and a rough surface.

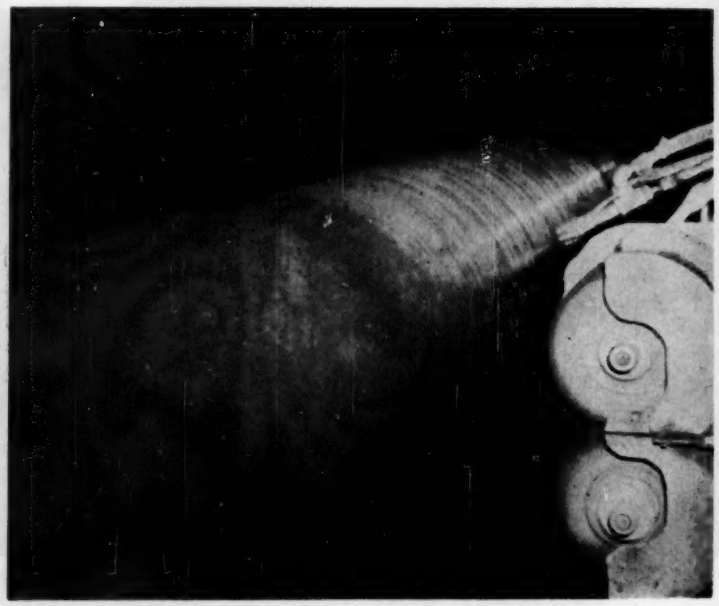
▶ **How to Apply**—There are, of course, a number of ways to apply these hard materials. Use of cast or wrought alloys as half-bushings, sleeves, or inserts is very popular. Bushings and half sleeves in journals, shafts and bearings, are good examples of solving wear problems with rotating parts. And wear-resistant insets are widely used, for example, as erosion shields on steam turbine blades.

Another way to apply these materials: spray techniques (*Chem. Eng.*, Mar. 21, 1960, p. 184). The spray hard-facing of pump plungers provides an abrasion-resistant deposit requiring a minimum of finishing. Spray hard-facing of fan blades, which may be subjected to abrasive solids, is a good example of this technique.

A third way to use hard materials involves putting down a layer with conventional welding techniques. Nickel-based alloys, weld deposited, are used on shearing blades and in high-temperature equipment. High-chrome irons are used in high-temperature piping, and on crusher rolls, conveyor chains. Cobalt alloys find use in valve parts, shearing blades and other applications requiring resistance to frictional heat. Tungsten carbide rods are used to provide resistance to sliding abrasion.

Relative Hardness of Hard-Facing Materials

	Knoop No.
Diamond	6,950–5,500
Chromium boride	2,900
Boron carbide	2,900–2,580
Silicon carbide (gray)	2,760–2,250
Titanium carbide	2,620–2,350
Aluminum oxide (alpha)	2,200–1,860
Tungsten carbide	2,140–1,570
Chromium carbide	1,960–1,672
Garnet	1,340–1,240
Cementite	940
Tool steel (hardened)	760– 730
Martensitic steel	640– 390
Austenitic steel	412
Ferrite	154



STEEL WIRE on concrete gets protective cement coating as . . .

Prestressed Concrete Pipe Gains Favor as Storage Tanks

An interesting trend seems to be shaping up for prestressed concrete: use of large-diameter concrete pipe as storage tanks—particularly for storing liquefied petroleum gas.

There's a good reason for this. Calculations show that the total cost of a buried, prestressed concrete pipe-vessel for LPG is roughly 75% of an above-ground steel unit (at around 30,000 gal.). For very large volumes, saving would be even larger, according to one of the producers, Lock Joint Pipe Co., Wharton, N. J.

▶ **Lengths of Pipe** — Actually these concrete "vessels" are lengths of large-diameter pipe joined together. The pipe, of course, is not new. Dow Chemical, for instance, uses it for seawater lines at Freeport, Tex. (*Chem. Eng.*, Aug. 1957, p. 300). But Lock Joint has a storage

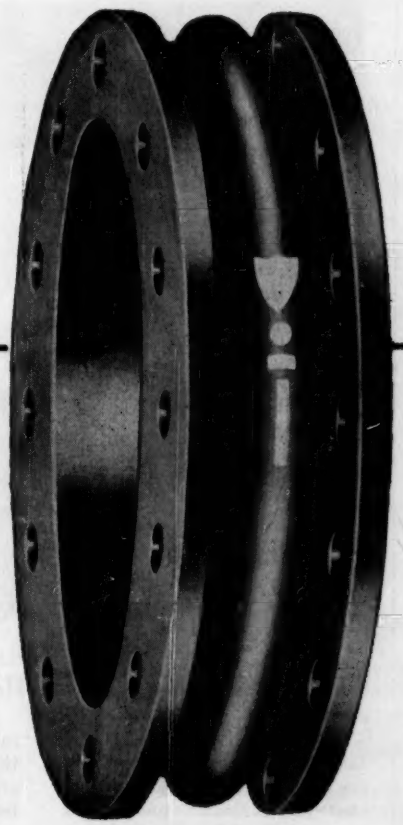
EXPANSION JOINTS

THEY STAY FLEXIBLE
when handling the most severe chemicals

"U.S." Expansion Joints of butyl rubber construction are recommended for handling certain chemicals.

Typical of these are:

ANILINE-R.T.
DIETHYL SEBACATE-R.T.
HYDROCHLORIC ACID (37%) UP TO 122° F
SODIUM HYDROXIDE (20-50%) UP TO 158° F
SODIUM HYPOCHLORITE (20%) UP TO 158° F
SULFURIC ACID (50%) AT R.T.



"U.S." Expansion Joints remain completely flexible at all times. Joints made of neoprene or natural rubber stiffen up, crack and fail when handling the above chemicals.

For the most severe service, specify "U.S." Expansion Joints lined with Teflon. These "U.S." Joints are ideal for handling most chemicals and solvents.

"U.S." Expansion Joints are in use in every kind of industry. Some of these joints have been on the job since 1924, the year "U.S." invented them! Long-lived, they *prolong the life* of equipment in pressure and vacuum systems.

• • •

When you think of rubber, think of your "U.S." Distributor. He's your best on-the-spot source of technical aid, quick delivery, and quality industrial rubber products.

Mechanical Goods Division
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WORLD'S LARGEST MANUFACTURER OF INDUSTRIAL RUBBER PRODUCTS
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unit at its Wharton, N. J., plant: 30,000-gal. capacity, consisting of 16-ft. lengths of 60-in. I.D. pipe, buried underground. This is a straight run of pipe, but Lock Joint claims there's no limit to size or physical configuration. The pipe could be laid out in concentric circles—7,150 ft. of 60-in. pipe could store 1-million gal. of LPG.

Rectangular grids or long parallel lines are possible. And pipe can be produced with diameters of 36 to 144-in.

Besides low first cost, the pipe has other advantages:

- Virtually no maintenance.
- No fire hazard.
- Generally a constant product temperature.
- Reduced insurance costs.
- The ground above the storage unit can be used for other purposes.
- Unsightly containers are eliminated in locations with zoning or aesthetics problems.

▶ **Constant Temperature** — Part of the answer to frequently operated large-volume storage is a container which automatically maintains constant, low temperatures. An investigation of soil temperatures showed that, even in Texas, the highest temperature recorded at a depth of 4 ft. was 72 F. At 72 F. commercial propane has a vapor pressure of 125 psi. Product temperature quickly approaches ground temperature in either warm or cold weather. This has been proved by actual recordings on the Wharton, N. J., concrete storage tank.

▶ **How to Join Pipe**—The pipe, of course, also has to be absolutely gas tight. It contains a steel cylinder, seam welded, with bell and spigot joint rings attached to the ends.

This unit is then, after pressure testing, mounted vertically between inside and outside molds. Concrete is poured into the annular space between the molds, coating both surfaces of the steel cylinder.

After curing, core is placed on a special tension winding machine where steel wire is wound over the concrete—placing the concrete under compression. Then cement mortar or concrete is sprayed or poured on, coating the wire.

The spigot ring has an annular groove to confine a round synthetic rubber gasket. This gasket is stretched and placed in the groove before lengths of pipe are joined. When the spigot is inserted into the bell, the gasket is compressed from a round to a rectangular shape, forming a tight, flexible joint. Poured mortar completes the joint.

Unique Ceramic Conducts Heat but Not Electricity

Beryllium-oxide ceramics are fast becoming a vital material for missiles and rockets. Reason: the ceramic's novel split personality of conducting heat but, at the same time, acting as an electrical insulator. When beryllium-oxide components are used in missiles, they isolate components electrically, but don't need weight-grabbing cooling fins, fans and blowers. In this way size and weight of an already-miniaturized missile telemetry amplifier was cut 35%.

In addition to this, according to one producer, National Beryllia Corp., North Bergen, N. J., beryllium oxide is an excellent refractory material with light weight, high hardness, high hot strengths.

Process-Industries Corrosion Problems

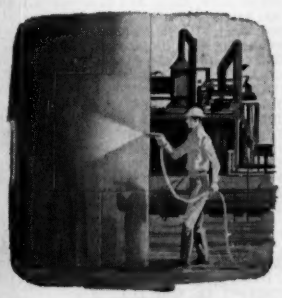
A short course on corrosion problems in the process industries will be held at Ohio State Univ., Sept. 12-16, 1960, jointly sponsored by Nat. Assn. of Corrosion Eng. (Houston, Tex.) and the university. Enrollment will be limited to about 150 persons.

Majority of the instructors will come from industry. Problems in processing acids, alkalis, chlorine and compounds, high and low-temperature corrosion will be covered as well as important characteristics of metals and plastics.

AMERCOAT: COMPLETE CORROSION PROTECTION

No one coating is ideal for all applications. A coating which gives outstanding protection against strong alkalies may fail completely when exposed to acids or severe weathering.

In order to provide complete corrosion protection, the Amercoat Corporation manufactures more than 40 completely different products, each formulated to give maximum corrosion protection for specific applications. As new processes and techniques alter exposures and requirements, Amercoat's continuing research develops new products to meet those requirements. Also, advanced research and testing upgrades and improves existing products to maintain maximum protection and enduring, maintenance-free life. Amercoat protective coatings, ranging from vinyls to epoxies to phenolics, are tailor-made for long-range protection and economy in tough applications.



BONDSTRAND—A corrosion resistant, high strength, glass reinforced epoxy pipe.

Typical applications: Acid lines, waste process water, ducting for air or fumes, process lines.

DIMETCOTE—100% inorganic, zinc silicate coating

Typical applications: Tank exteriors, structural steel, cooling towers, and as a permanent primer.

AMERCOAT No. 86—A synthetic resin primer especially formulated for exceptional adhesion and compatibility with various surfaces. Can be overcoated with vinyl or epoxy coatings.

AMERCOAT No. 33—Vinyl maintenance coating unexcelled for water immersion, chemical spillage or corrosive fumes.

Typical applications: Plating tanks, tank car exteriors, structural steel, caustic tanks, tank exteriors.

AMERCOAT No. 66—A high build epoxy for tank lining or exterior maintenance coating.

Typical applications: Brine tanks, structural steel in processing areas.

AMERCOAT No. 78—An easily applied coal tar epoxy which provides exceptional resistance to water and a wide range of chemicals.

Technical data available on request. Write to:

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INDUSTRY NEWS . . .

(*Continued from p.* 80)

Weston Paper & Manufacturing Co. is installing a new, 150-ton/day semi-chemical pulp mill at Terre Haute, Ind. To be designed and constructed by The Rust Engineering Co. of Pittsburgh, it will use hardwood rather than straw as its raw material in making paper liner boards.

Texas Gulf Sulphur Co. announces that its first test well on potash leases in southeastern Utah has given favorable results. The area where the well was drilled formerly belonged to the Delhi-Taylor Oil Corp.; now, Texas Gulf is developing the property under an agreement whereby Delhi-Taylor retains 25% interest.

California Spray-Chemical Corp. recently started up its new plant, shown above, which produces ammonium nitrate, ammonium nitrate solutions and complex fertilizers. The $5-million facility is at Kennewick, Wash. In making fertilizers the plant uses nitric acid rather than sulfuric acid to break down phosphate rock, and its nitric acid unit produces over 150 tons/day of 100% product. Other capacities are as follows: 200 tons/day ammonium nitrate solution, or 150 tons/day dry ammonium nitrate; 300 tons/day pelleted complex plant foods; and 200 tons/day liquid fertilizer.

U. S. Gypsum Co. has announced that it plans to build a new gypsum plant at Baltimore. It will be the company's seventh gypsum plant on the Eastern Seaboard. Construction is to

G-B SNAP*ON DISTRIBUTORS

LISTED IN YELLOW PAGES
(See ad on facing page)

AKRON, Ohio, The Asbestos Supply Co.
ALBANY, Ga., Industry Insulation Co.
ALBANY, N. Y., Hudson Valley Asbestos Corp.
ALBUQUERQUE, N. M., Mt. States Insulation Co.
AMARILLO, Tex., McDonald Engineering & Insulating Co.
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AUSTIN, Tex., Cinbar Engineering Co.
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Shook & Fletcher Supply Co.
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BOSTON, Mass., Homans-Kohler, Inc.
BUFFALO, N. Y., Industrial Insulation Sales, Inc.
BURLINGTON, Vt., Pipeline Insulators, Inc.
CHAMPAGNE, Ill., Lewie David Co.
CHARLESTON, W. Va., Asbestos & Insulating Co.
CHARLOTTE, N. C., D&B Insulation Co.
CHICAGO, Ill., E. C. Carlson Co.
Culberg Asbestos & Cork Co.
CHILLICOTHE, Ohio, Southern Ohio Insulating Co.
CINCINNATI, Ohio, R. E. Kramig Co.
CLEVELAND, Ohio, Ohio Asbestos & Insulation Co.
COLUMBIA, S. C., Industrial Insulation Div. of Richland Oil Co.
COLUMBUS, Ohio, Santeler Brothers
Culberg of Ohio
CORPUS CHRISTI, Tex., Precision Insulation Co.
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WASHINGTON, D. C., Walter E. Campbell Co., Inc.
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WICHITA, Kans., General Metals, Inc.
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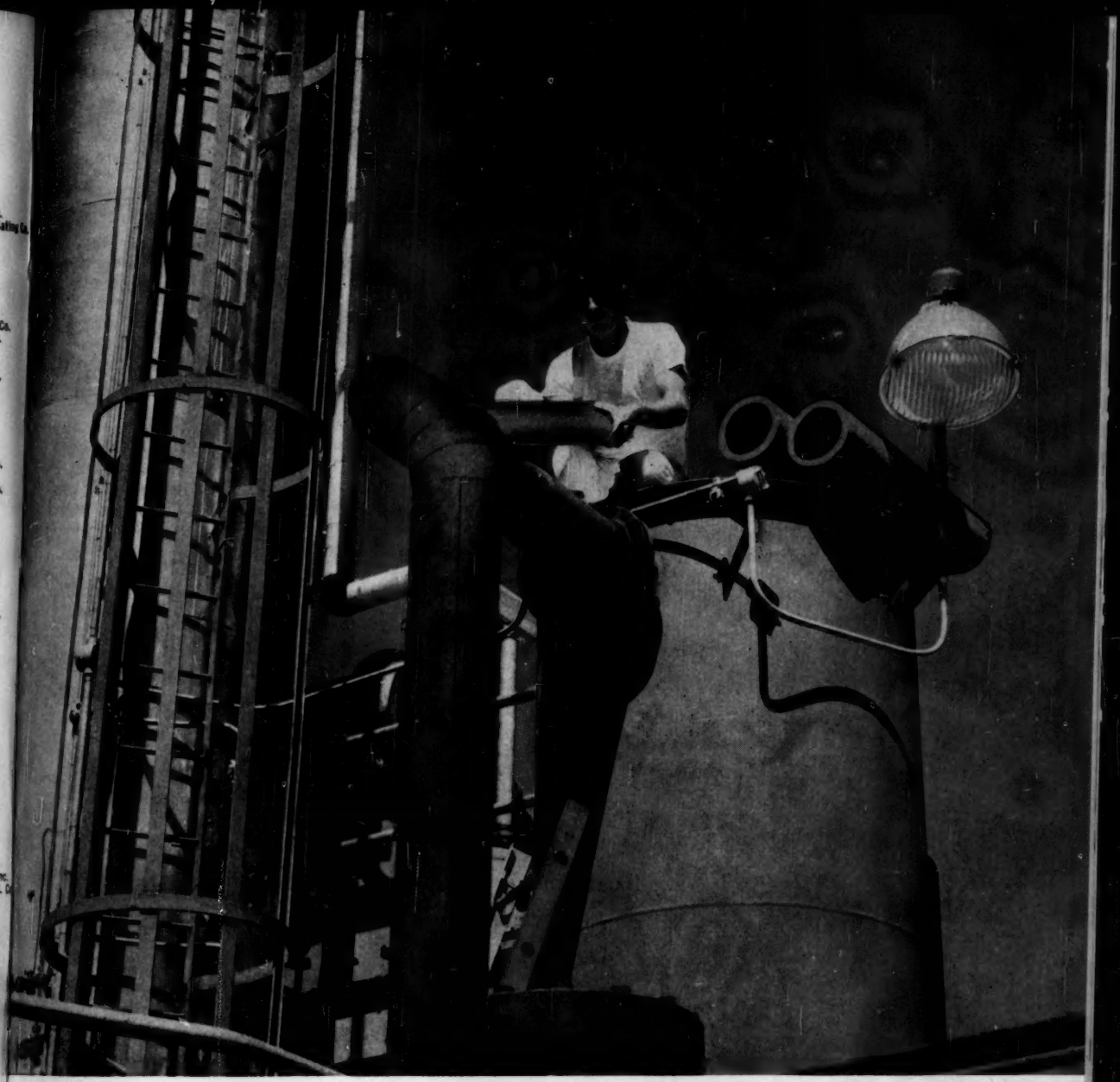

It would have been a tough insulating job ...except for G-B SNAP*ON®

You save all kinds of time and money when you insulate "hard-to-get-to" pipe with G-B Snap*On, the one piece pipe insulation molded of fine glass fibers. It's easy to carry 3-ft. G-B Snap*On sections to the job—even if you have to crawl or climb there . . . and they snap on pipe in one easy motion. No worry about breakage, for rough treatment won't harm G-B Snap*On. It's safer, too, because workmen can concentrate on their footing—and forget about dropping the insulation!

Add to these advantages the unequalled ease and economy of applying G-B Snap*On on straight runs, its superior thermal efficiency and permanence —and you can readily understand why G-B Snap*On is industry's No. 1 choice for heated or cold lines. It's available plain or with a variety of jackets, in sizes from copper tubing to 36", so there's a size and type just *made* for your next job!

FOR INFORMATION AND PROMPT DELIVERY SEE YOUR G-B SNAP*ON DISTRIBUTOR (LISTED IN ADJOINING COLUMN)

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Thermal and acoustical glass fiber insulations . . . Molded glass fiber pipe insulation
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DAY

Pneumatic Conveying & Bulk Storage News

FREE! 2 valuable guides for selecting PNEUMATIC CONVEYING and BULK STORAGE TANKS

BULLETIN M-588—12 page DAY pneumatic conveying guide just off the press. Discusses types of systems, illustrates and diagrams high and low density arrangements, shows equipment and tells "why" and "wherefore" of all types of pneumatic conveying including so-called fluidizing systems.

BULLETIN 574—12 pages, describes horizontal and vertical storage tanks. Points out savings and is filled with photos of various installations plus description of auxiliary equipment.

Whatever your pneumatic conveying or bulk storage problem, look first in these DAY bulletins. They are valuable aids in selecting and ordering the right equipment for your plant. For your free copies use reader service card of this magazine or write direct toDAY.

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EQUIPMENT ONLY OR A COMPLETE SYSTEM

start in 1961, and to be finished in early 1962.

Allied Chemical Corp.'s General Chemicals Division reports that its new liquid-aluminum-sulfate plant near Los Angeles is on stream. Located at the division's El Segundo production center, it is General Chemical's twenty-ninth facility producing dry or liquid alum in the U. S. and Canada.

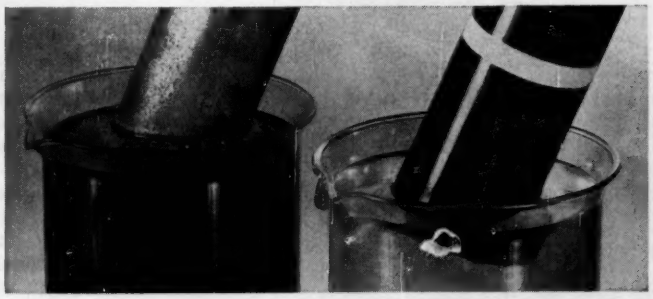
National Gypsum Co. has completed a new gypsum plant at Lorain, Ohio. The plant represents the final phase of the firm's $25-million Great Lakes production network project.

Koppers Co., Inc., is expanding its Oil City, Pa., plant so that it can produce a broader line of alkylated phenols there. New phenol products will include p-tertiary butyl phenol, p-tertiary amyl phenol and di-tertiary amyl phenol.

Diamond Alkali Co.'s Chlorinated Products Division is starting the first phase of a long-range expansion program for its plant at Belle, W. Va. This initial phase will include modernization of the facilities in which the plant makes methyl chloride, methylene chloride, and chloroform.

Air Products, Inc., recently built the helium liquefier shown above. The mobile unit, assembled for the U. S. Navy, is said to be the world's largest helium liquefaction plant, with a daily output corresponding to 45,000 standard cu. ft. It is the prototype of an even larger unit to be built in the future.

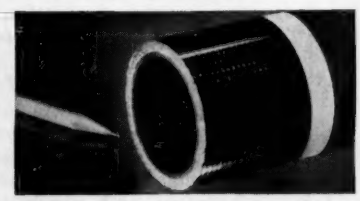
Goodyear Tire & Rubber Co. is planning to add new manufacturing capacity at two lo-



TEST PROVES CORROSION RESISTANCE... Stainless Steel 316 pipe (at left) and Fibercast Pipe were tested in 54% P_2O_5 solution at 290° F using modified ASTM A-262-55T formula. The stainless steel pipe showed .778" penetration per month; yet the Fibercast showed no deterioration whatsoever.

New pipes eliminate corrosion problems in processing industries!

Chemical processing industries discover that new Fibercast® Pipe and Fittings perform indefinitely with extremely corrosive elements and high temperatures . . . even where other nonmetallic pipes fail.



WHAT is Fibercast?

It is centrifugally cast, thermoset, epoxy resin reinforced pipe that handles temperature and pressure problems where no other pipe will do. Its body of woven glass fibers resists high tension forces, is embedded and bonded by heat in epoxy resin. Result: strong, long-lasting pipe that resists high pressures and temperatures in corrosive environments.

WHEN should Fibercast be used?

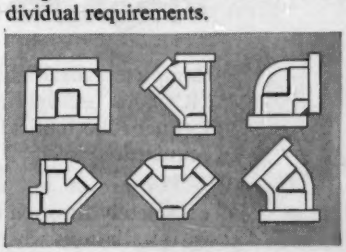
Whenever ease of handling, light weight, dielectric properties and structural stability are desirable in a piping material that is at the same time outstandingly resistant to heat, pressure and particularly corrosion.

Examples: Petroleum industry . . . chemical . . . petro-chemical . . . nuclear energy . . . textile . . . paper . . . food-processing . . . and countless other operations handling acids, alkalies, salt water and other corrosive liquids under pressure.

WHY use Fibercast?

Fibercast's remarkable lasting qualities . . . its amazing resistance to "impossible" temperature and pressure conditions . . . make it a long-lived, cost-saving, maintenance-saving pipe. Remember, too: Fibercast has the world's most complete stock of standard fittings, as well as couplings designed and made to order for individual requirements.

Workman is shown with section of Fibercast pipe bearing 32% HCl at a Shell chemical plant. Note that Fibercast has sufficient strength for installation on span racks with the spacing normally used for metal pipe.



If you would like to learn more about the uses of Fibercast in chemical industries, mail the coupon below.

FIBERCAST COMPANY
Box 727, Sand Springs, Okla.

Please send me further information about Fibercast Tube and Pipe.

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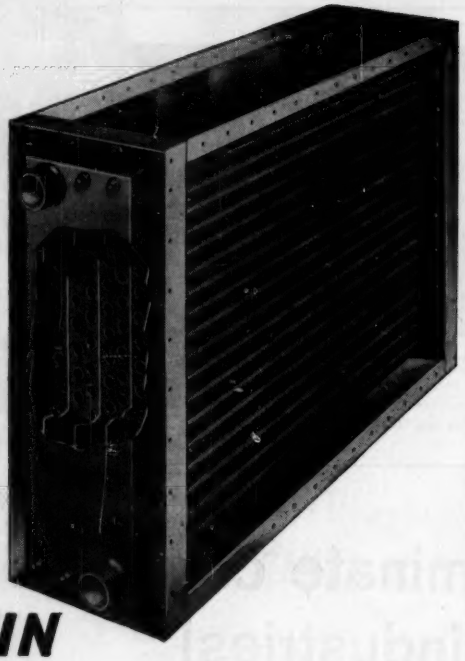


AEROFIN

TYPE R Removable-Header WATER COILS

- Complete Drainability
- Easily Cleaned
- High Heat Transfer

Completely drainable and easily cleaned, Aerofin Type "R" coils are specially designed for installations where frequent mechanical cleaning of the inside of the tubes is required.

The use of 5/8" O.D. tubes permits the coil to drain completely through the water and drain connections and, in installations where sediment is a problem, the coil can be pitched in either direction. The simple removal of a single gasketed plate at each end of the coil exposes every tube, and makes thorough cleaning possible from either end.

The finned tubes are staggered in the direction of air flow, resulting in maximum heat transfer. Casings are standardized for easy installation.

Write for Bulletin No. R-50

AEROFIN CORPORATION

101 Greenway Ave., Syracuse 3, N.Y.

Aerofin is sold only by manufacturers of fan system apparatus. List on request.

cations. A multi-million-dollar plant to produce synthetic rubber will be built near Beaumont, Tex.; it will obtain its principal raw materials from Mobil Oil Co.'s Beaumont refinery. In addition, Goodyear will expand its vinyl resin production facilities at its plant in Niagara Falls, N. Y. This $1-million project will add about 20 million lbs./yr. to the plant's total capacity, and it is expected to be completed by this fall.

Seawater Conversion Corp. is the name of a new company formed jointly by W. L. Badger Associates, Inc. (Ann Arbor, Mich.) and Kaighin & Hughes, Inc. (Toledo, Ohio). Its objectives are to design, engineer, build and operate fresh-water production facilities throughout the world.

National Distillers & Chemical Corp. has formed a new subsidiary company which will produce special metals such as molybdenum, columbium, hafnium and tungsten. National Distillers formed the new firm, which is known as Reactive Metals Inc., by combining the operations of two ND subsidiaries, Johnston & Funk Metallurgical Corp. and Mallory-Sharon Metals Corp. This move came after National Distillers acquired a majority interest in Mallory-Sharon this spring.

H. K. Porter Co. of Pittsburgh has acquired the assets of Allied Paint Mfg. Co., Tulsa, Okla. Former Allied operation is now the Tulsa Works of Porter's Paint Division.

American Machine & Foundry Co. recently purchased the Maxim Division of Emhart Mfg. Co. Maxim, located in Hartford, Conn., manufactures equipment for convert-

ing sea water to fresh water by distillation, as well as other industrial equipment.

Bausch & Lomb Inc. is the new company name selected by the former Bausch & Lomb Optical Co. By changing its name B&L reflects its expansion of interests into fields other than optics alone.

The Flintkote Co., a manufacturer of building products, has acquired all outstanding stock of The Sealzit Co. of Riverside, Calif. Sealzit manufactures equipment for application of resins, binders and plastics.

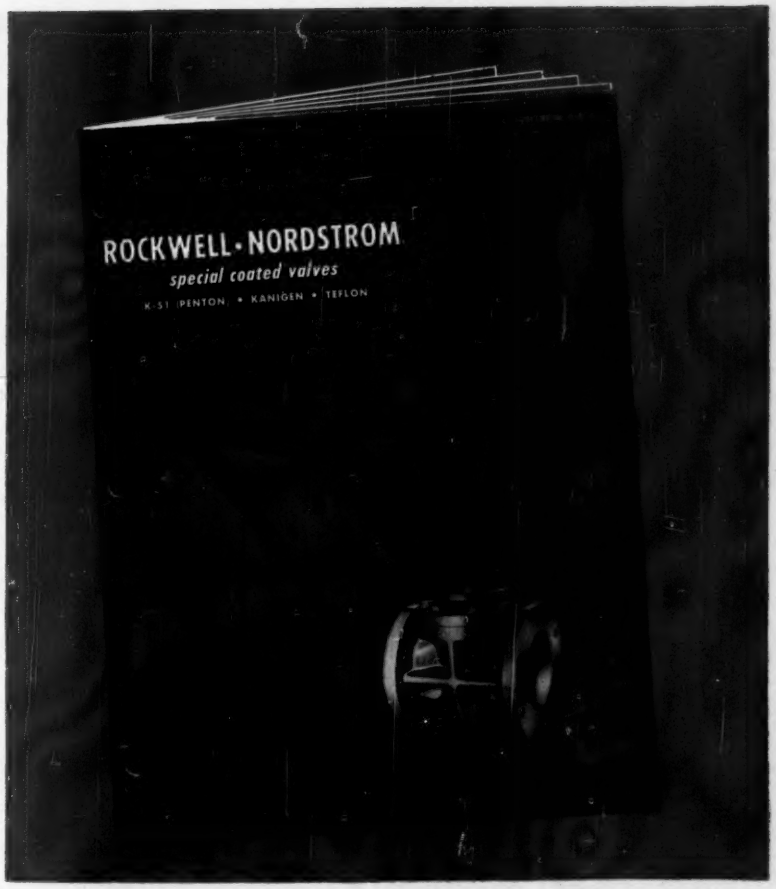
Dorr-Oliver Inc., of Stamford, Conn., has set up two new functional sales divisions within its Industrial Sales Area. One division will concern itself with customers in the petroleum and petrochemicals industries, and the other will deal with customers in the pulp and paper industries.

Reliance Varnish Co., of Louisville, Ky., and **Coast Paint & Lacquer Co.,** of Houston, have merged. Combined assets of the two companies exceed $7 million.

OVERSEAS BRIEFS

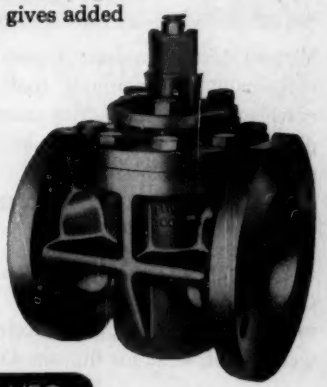
Japan: A synthetic rubber plant costing $30 million was dedicated recently at Yokkaichi. Owned by Japan Synthetic Rubber Co., Ltd., the facility was designed to produce 40,000 metric tons of SBR crumb rubber and 5,000 metric tons of latex annually. Plant was designed by Blaw-Knox Co. of Pittsburgh.

Puerto Rico: Union Carbide Corp. announces that its wholly owned subsidiary, Union Carbide Caribe, Inc., will build and operate a polyethyl-



Get this NEW BOOKLET on ROCKWELL—NORDSTROM Valves with Teflon Coated Plugs

Rockwell-Nordstrom standard pattern valves with Teflon coated plugs are now available for use where infrequent or inadequate plug valve lubrication might be expected. The coating of tough Teflon gives added lubricity to the plug for longer valve life and easier operation. For complete information on Teflon, as well as corrosion resisting K-51 (Penton) and Kanigen coatings, write for the new booklet on special coated valves to: Rockwell Manufacturing Co., Pittsburgh 8, Pa. Canadian Valve Licensee: Peacock Brothers Limited.



ROCKWELL-Nordstrom VALVES
another fine product by
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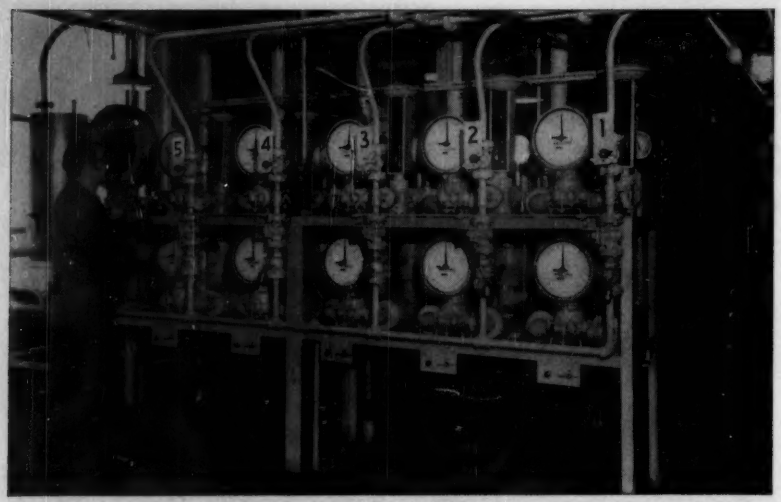

Battery of Niagara Chemical Meters measuring and controlling flow of CS_2 at Dupont's Buffalo Film Department Plant.

NIAGARA METERS
Contribute to the Quality of DuPont CELLOPHANE

Quality Control begins with Accurate Measurement of Components

Wherever liquids are moved, processed or consumed, Niagara Meters can perform the double function of accurate measurement plus control. The flow of liquid can be stopped after a preset gallonage has been measured . . . other control mechanisms can be actuated . . . pump motors can be shut off . . . audible or visual signals can be transmitted to the operator.

Niagara Meters measure liquids volumetrically by the simple (only one moving part in the measuring chamber) displacement method that assures constant accuracy. Whatever the liquid, whatever the function, there is a Niagara Meter that will do the job.

For a complete description of Niagara Chemical Meters, including High Pressure, Steam-Jacketed, and Electricontact Models, write for Bulletin 43.

BUFFALO METER COMPANY
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Subsidiary of American Meter Company, Inc.
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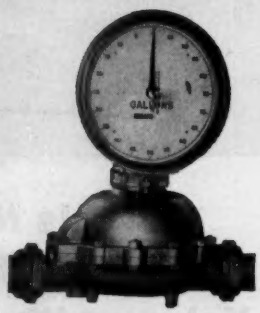
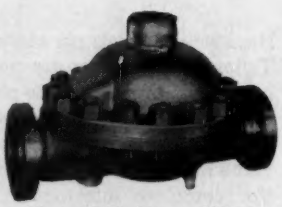


Niagara Electricontact Meter. Available for all types of liquids.



Niagara High Pressure Meter. For pressures up to 5000 psi.

Niagara Steam Jacketed Meter for materials requiring steam heat to maintain fluid condition.

ene plant near Ponce on the southern coast of Puerto Rico. Plant will have an initial annual capacity of 110 million lbs. plastic, which will be the largest initial production capacity of any polyethylene plant in the world. It is to serve all world markets, and is expected to begin operating during the second half of 1962.

East Germany: The Chemical Works Buna announces that work is under way to add four new carbide furnaces at its facilities in Schkopau. Plant already has eight such furnaces, and its expanded capacity will be about 800,000 tons/yr. calcium carbide. The expansion will cost over $20 million. Company uses carbide mainly to make synthetic rubber.

Finland's Ministry of Commerce and Industry has signed a contract with General Dynamics Corp., of California, for the country's first atomic reactor. It will be a TRIGA reactor, and will be fueled with uranium drawn from the International Atomic Energy Agency's world pool of fissionable material. The installation will serve as nucleus of a new research and training center near Helsinki.

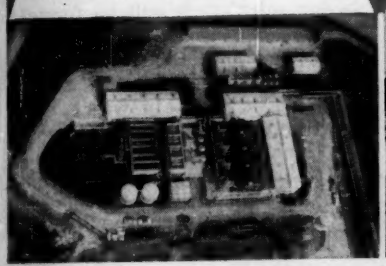
Canada: A new refinery, owned by British Petroleum Refinery Canada, Ltd., has been completed near Montreal. It has a capacity of 25,000 bbl./day, and has been designed to produce a good yield of high-octane motor gasoline together with kerosene, diesel oil, furnace oils, heavy fuel oil and LPG. It is the BP (British Petroleum) Group's first refinery in North America.

Argentina: A new phenol plant, with planned capacity of 25 metric tons/day, will be built at Rio Tercero. It will be operated by Duranor, a joint subsidiary of Hooker Chemical Corp. (Niagara Falls, N. Y.) and an Argentine chemical firm named Atanor. Plant site, some 450 mi. north-

SULPHUR

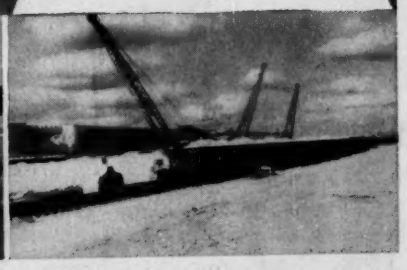
POINTS OF DEPARTURE

FANNETT, TEXAS



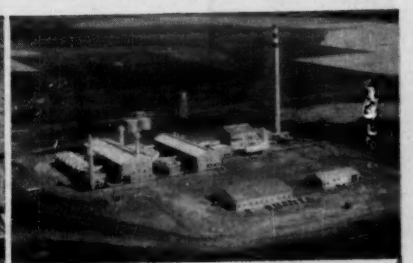
MOSS BLUFF, TEXAS

NEWGULF, TEXAS



SPINDLETOP, TEXAS

WORLAND, WYOMING



OKOTOKS, ALBERTA

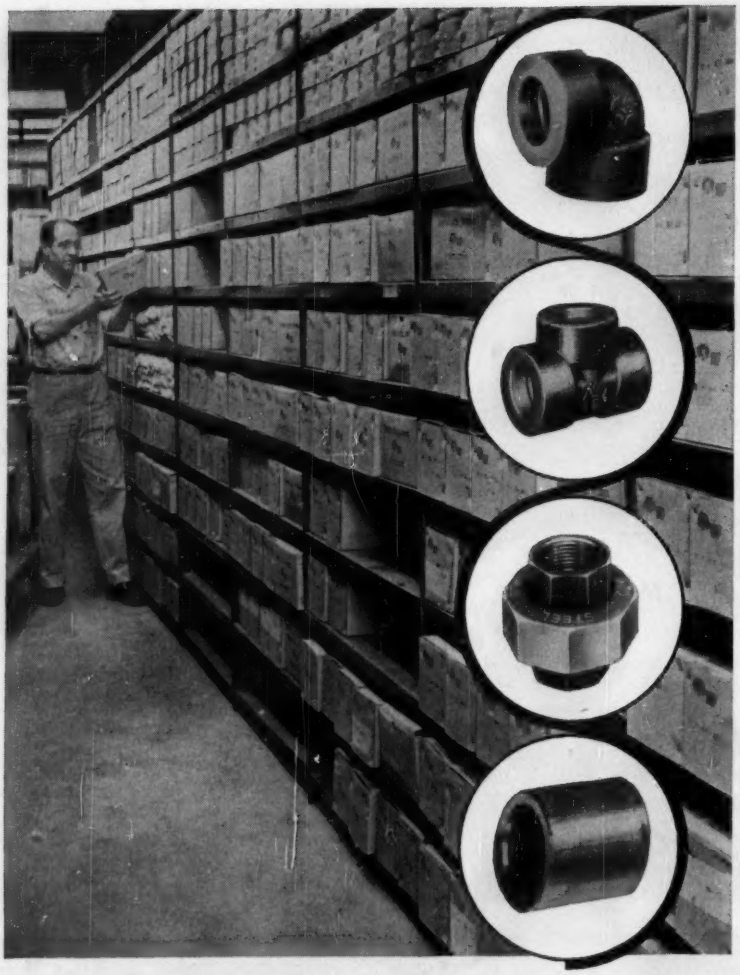
Solid or Molten Sulphur to all users in the United States and Canada

In addition to these six producing properties, stocking and distribution centers are being set up, thus broadening the TGS Service to industry. Ample supplies of both molten and solid sulphur will be available at these centers. Cincinnati, the first of these units, is now in full operation.

TEXAS GULF SULPHUR COMPANY

75 East 45th St., New York 17, N. Y.
811 Rusk Ave., Houston 2, Texas

Sulphur Producing Units: Newgulf, Texas • Spindletop, Texas • Moss Bluff, Texas • Fannett, Texas • Worland, Wyoming • Okotoks, Alberta, Canada



"Off The Shelf" Deliveries for W-S FORGED FITTINGS

Inventories like these are an everyday service of W-S stocking distributors. As near at hand as your telephone.

While we're on the subject of inventories, we'd like to mention our packaging. Practically all types and sizes of fittings in any "mix" can be packed in a convenient W-S Case or Half-case . . . each type and size in its own carton.

Specify W-S on your next order. For specifications and Distributor locations, write *Forge & Fittings Division, H. K. Porter Company, Inc., Box 95, Roselle, New Jersey.*

FORGE AND PORTER FITTINGS DIVISION

H. K. PORTER COMPANY, INC.

PORTER SERVES INDUSTRY with steel, rubber and friction products, asbestos textiles, high voltage electrical equipment, electrical wire and cable, wiring systems, motors, fans, blowers, specialty alloys, paints, refractories, tools, forgings and pipe fittings, roll formings and stampings, wire rope and strand.

west of Buenos Aires, is adjacent to an existing Atanor plant.

Australia: Sterling Pharmaceuticals Pty. Ltd., a subsidiary of Sterling Drug Inc., recently completed a $2.5-million pharmaceutical manufacturing plant and laboratory at Sydney. The facilities represent the fifth time that the company has expanded its operations at Sydney.

Mexico: The first Mexican plant for making ceramic opacifiers has gone on stream. Located at Monterrey, it is operated by Industrias M&T de Mexico, a subsidiary of Metal & Thermit Corp. of New York.

Australia: A new, jointly owned chemical firm will be formed by Monsanto Chemicals (Australia) Ltd. and Consolidated Zinc Pty. Ltd., to manufacture products in which both companies have an interest. Such products include mainly fluorine derivatives, and initially the new firm will produce fluorocarbons, which are not manufactured in Australia at present. The fluorocarbon facilities will be located at Monsanto's existing plant site at Sydney, and will probably be on stream about a year from now.

El Salvador: Sherwin-Williams Co. de Centro America, S.A., has started up a new paint plant at San Salvador. The plant is owned by stockholders in Costa Rica, El Salvador, Guatemala, Honduras and Nicaragua, the countries which have entered the Central American common market pact. Initial production capacity will be about 250,000 gal./yr. The plant cost $400,000.

Australia: Allied Chemical Corp. of New York, and Polymer Corp. Pty. Ltd., of Australia, have announced plans to form a joint company to initially produce nylon tire cord, monofilament and molding compounds. The new company is to be called Allied Polymer Pty. Ltd.

Sulfation or sulfonation in your process ?

STABILIZED

TRIOSUL®

MONSANTO'S NEW LIQUID SO_3

ENDS VAPORIZER "CLEAN-OUT" HEADACHES

AND REDUCES CONTAMINATION HAZARDS

Monsanto's new TRIOSUL contains a unique stabilizer which vaporizes without leaving sludge or crystalline residues—ends the messy, hazardous, "time-eating" chore of frequent vaporizer and storage tank clean-outs—cuts costly process down time! It also tolerates more water and acid contamination than previously considered possible.

Per pound, TRIOSUL offers far more available SO_3 than oleum or other forms of sulfuric acid—is the most efficient source of SO_3 you can use. It invites innovations such as reaction in inert organic solvents, and opens the way to your production of high-assay product by *direct* reactions never before possible, even with oleum.

Because no water is formed in TRIOSUL sulfonations, it eliminates spent acid—frees you from waste-disposal problems—gives you more reactor capacity. It lets you produce salt-free products having high clarity. It is ready for you now in steel drums and tank cars. Write for more details, or use the convenient coupon.

Monsanto

MONSANTO CHEMICAL COMPANY
Inorganic Chemicals Division
Dept. 3016, St. Louis 66, Missouri

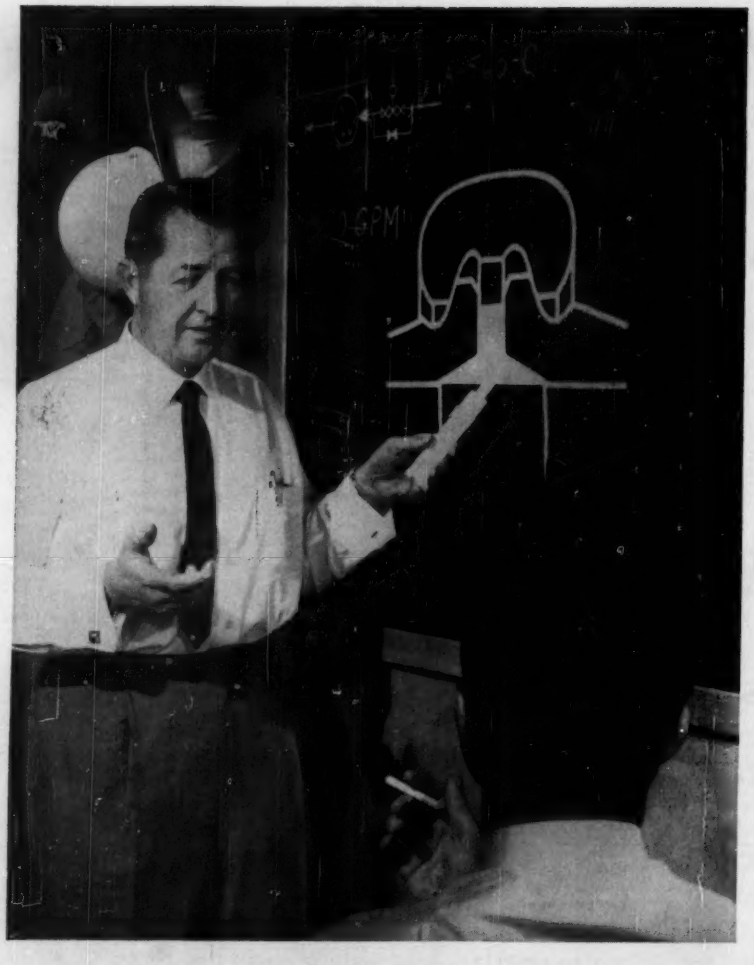
Please send me Monsanto's Technical Bulletin I-178 on TRIOSUL.

Name..... *Title*.....

Company.....

Address.....

City..... *Zone*..... *State*.....



New GRAYLOC® Seal Eliminates Leaks

GRAYLOC is practical where leakage is a problem, regardless of high or low pressure, where savings in money, space, weight or time are desirable.

The GRAYLOC seal design, a new principle in pipe connection, is simple: tapered lips on either side of a rigid rib. The seal lip tapers slightly less than the mating hub, forming a line seal as the components touch. As the connection bolts are tightened, the lips deflect to form a positive, leak-proof surface seal. GRAYLOC Connections can be made and released repeatedly and still operate to pressure without seal ring replacement.

GRAYLOC works in most flange applications. If you are interested in more information about how GRAYLOC can solve your leakage problems and save you money, write for the new GRAYLOC CATALOG on your company letterhead. No charge, no obligation.

GRAYLOC SALES DIVISION

GRAY Tool Company

P.O. BOX 2291 HOUSTON 1, TEXAS REpublic 4-1641 04

CALENDAR

Pennsylvania State University, under water missile engineering seminar.
July 10-22 University Park, Pa.

Gordon Research Conference, Statistics in Chemistry and Chemical Engineering, New Hampton School.
July 11-15 New Hampton, N. H.

Gordon Research Conference, Corrosion, Colby Junior College.
July 18-22 New London, N. H.

Massachusetts Institute of Technology, Dynamics and Control of Chemical Engineering Processes.
July 18-29 Cambridge, Mass.

Western Packaging & Materials Handling Exposition, Los Angeles' Pan Pacific Auditorium.
July 19-21 Los Angeles, Calif.

Gordon Research Conference, Separation and Purification, Colby Junior College.
July 25-29 New London, N. H.

Gordon Research Conference, Instrumentation, Colby Junior College.
Aug. 1-5 New London, N. H.

University of California, Gas Chromatography.
Aug. 2-5 Los Angeles, Calif.

Gordon Research Conference, Organic Coatings, New Hampton School.
Aug. 8-12 New Hampton, N. H.

Technical Assn. of the Pulp and Paper Industry, 9th Pulp and Paper Statistics Course, Brevard College.
Aug. 8-19 Brevard, N. C.

American Institute of Chemical Engineers & American Society of Mechanical Engineers, National Heat Transfer Conference and Exhibit, Statler Hotel.
Aug. 14-17 Buffalo, N. Y.

American Society of Mechanical Engineers, Heat Transistor Division Conference, Statler-Hilton Hotel.
Aug. 15-17 Buffalo, N. Y.

National Bureau of Standards, Cryogenic Engineers Conference.
Aug. 17-19 Boulder, Col.

Technical Association of the Pulp and Paper Industry, 14th Alkaline Pulping Conference, Multnomah Hotel.
Aug. 22-24 Portland, Ore.

University of Colorado, 1960 Cryogenic Engineering Conference.
Aug. 23-25 Boulder, Col.

Association For Computing Machinery, National Meeting, Marquette University.
Aug. 23-25 Milwaukee, Wisc.

Technical Association of The Pulp and Paper Industry, Forest Biology Conference.
Aug. 24-27 Seattle, Wash.

The Combustion Institute, 8th International Symposium, California Institute of Technology.
Aug. 28-Sept. 2 Pasadena, Calif.

Public Health Service, Water Quality Measurement and Instrumentation Symposium, Sanitary Engineering Center.
Aug. 29-31 Cincinnati, Ohio

Air Force Office of Scientific Research, 8th International Combustion Symposium.
Aug. 29-Sept. 2 Los Angeles, Calif.

Chemical Institute of Canada, Nuclear and Radio-Chemistry Symposium, Chalk River Laboratories.
Sept. 6-8 Chalk River, Ontario

Production Engineering Show, Navy Pier.
Sept. 6-16 Chicago, Ill.

Machine Tool Show, International Amphitheatre.
Sept. 6-16 Chicago, Ill.

Massachusetts Institute of Technology, Joint Automatic Control Conference.
Sept. 7-9 Cambridge, Mass.

American Chemical Society, National Meeting.
Sept. 11-16 New York, N. Y.

New York University, College of Engineering, 6th Annual Titanium Metallurgy Conference, University Heights.
Sept. 12-13 Bronx, New York City

Canadian Agricultural Chemicals Assoc., 8th Annual Meeting and Conference, Britannia Hotel.
Sept. 12-14 Muskoka, Ontario

American Society of Mechanical Engineers, Engineering Management Conference.
Sept. 15-16 Chicago, Ill.

American Institute of Chemical Engineers, National Meeting, Mayo Hotel.
Sept. 25-28 Tulsa, Oklahoma

American Society of Mechanical Engineers, Petroleum Mechanical Engineering Conference, Jung Hotel.
Sept. 26-28 New Orleans, La.

Instrument Society of America, Instrument-Automation Conference and Exhibit Coliseum.
Sept. 26-30 New York, N. Y.

International Electrostatics Conference, University of Grenoble.
Sept. 27-Oct. 1 Grenoble, France

Society of Plastics Engineering, Inc., Plastics vs. Corrosion, Mark Hopkins Hotel.
Oct. 5 San Francisco, Calif.

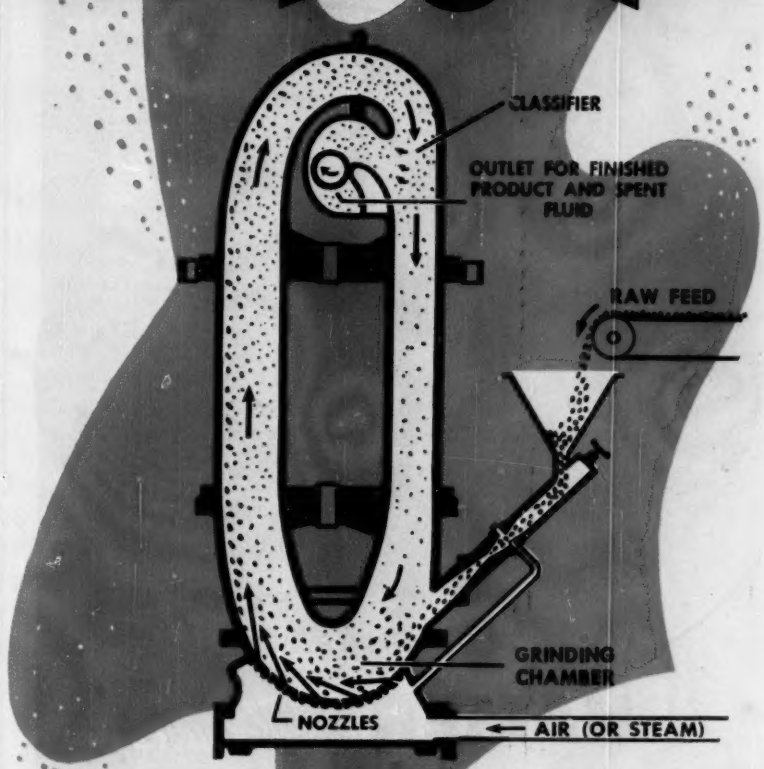
National Association of Corrosion Engineers, six regional conferences.
West, Sheraton-Palace Hotel
Oct. 6-7 San Francisco, Calif.
Southeast, Dinkler-Plaza Hotel
Oct. 6-8 Atlanta, Ga.
Northeast, Prichard Hotel
Oct. 11-14 Huntington, W. Va.
North Central, Pfister Hotel
Oct. 19-20 Milwaukee, Wis.
South Central, Mayo Hotel
Oct. 25-27 Tulsa, Okla.
Canadian (Eastern), Sheraton Mount Royal Hotel
Nov. 14-16 Montreal, Quebec.

The American Ceramic Society, Refractories Division Meeting, Bedford Springs Hotel.
Oct. 6-8 Bedford, Pa.

American Society of Mechanical Engineers, Rubber and Plastics Conference, Lawrence Hotel.
Oct. 9-12 Erie, Pa.

for GRINDING AND DEHYDRATION
FINER PARTICLES
LOW MAINTENANCE

FLUID ENERGY JET-O-MIZER MILLS



The Fluid Energy "Jet-O-Mizer" Mill, designed and built by the pioneers in fluid energy fine grinding, does far more than produce fine particles. It controls fineness and product quality with a narrow distribution range and simultaneously with grinding can dehydrate, coat particles, blend and achieve chemical changes.

Jet-O-Mizer Mills are being used all over the world, processing many types of materials in the following industries:

- Abrasive
- Food
- Pigment
- Wax
- Insecticide
- Mineral
- Plastic
- Metal
- Ceramic
- Pharmaceutical
- Carbon
- Chemical

"Jet-O-Mizing" produces **FINE PARTICLES** ¼ micron average and above **PLUS . . .** Narrow Particle Distribution • Dry, or Controlled Moisture Content • Continuous Operation • Uniformity of End Product • Other Operations with Grinding • No Attritional Heat — No Moving Parts • Low Operating Costs • Low Maintenance

Send for complete information on Fluid Energy's "Jet-O-Mizer" Mills, "Jet-O-Clone" Dust Collectors, and TESTING AND CUSTOM GRINDING services.

FLUID ENERGY PROCESSING & EQUIPMENT COMPANY
Richmond & Norris Streets, Philadelphia 25, Pa. • Phone: Regent 9-7728
(Formerly known as the Wheeler-Stephanoff Mill)

HAMER *Visible Shut-off*
LINE BLIND VALVES

HAMER PLUG VALVES

Will not stick or freeze. Perfect for hard-to-hold fluids. Simple plug adjustment nut eliminates sticking

Hamer Line Blinds are unsurpassed for positive action, easy operation, long-life service and lasting safety. One man can open or blind a line in less than one minute, and there is nothing like a solid plate for a PERMANENT LEAKPROOF SHUT-OFF. Bar or handwheel operation eliminates wedges, hammers, wrenches needed for spreading conventional flanges. Removes fire hazard of sparking and stops damage to equipment.

Hamer VALVES

MANUFACTURED AND SOLD BY
WELL EQUIPMENT MFG. CORP.
HOUSTON, TEXAS
Division of CHIKSAN COMPANY a subsidiary of FOOD MACHINERY AND CHEMICAL CORPORATION

fmc

WECO

(*Continued from page 96*)

tioners, air locks and air regulators.—**Republic Flow Meters Co., Chicago, Ill.** **96C**

Flared Tubing Seal

Eliminates leaks on flared tube ends and fittings.

Leaky connections on flared tubing systems can be eliminated, says manufacturer of seals for these joints. Shell-shaped seals snap on fittings; when joint is made and maximum pressure on the connection has been reached, seal conforms to the surface of the fitting, fills nicks and crevices through which leakage might occur.

Seal, which is self-adjusting for thread misalignment, can be used to rehabilitate fittings whose sealing faces have been scored from previous use, or to positively seal newly made-up joints. Units come in copper, aluminum, and soft nickel in size range from ¼- to 3-in.—**Del Mfg. Co., Los Angeles, Calif.** **180A**

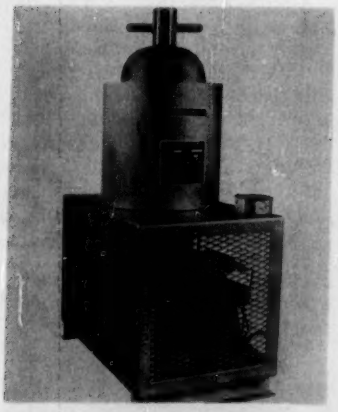
Asbestos Clothing

Light-weight safety garb reflects radiant heat.

No need to flinch when splashed with 3,000 F. molten metal if you are wearing Thermogarb. New asbestos safety

clothing will shed the hot drops without deterioration, loss of resiliency, or discoloration of inner side. Specially woven fabric is claimed to be 40 to 50% tougher against abrasion and four times stronger than other fabrics of the same weight and thickness.

Garments reflect about 50% of radiant heat, also offer protection against glass, chemicals, ceramics and oils. Line includes coats, leggings, cape sleeves, coveralls, sleevelets, pants, chaps and aprons—in white or yellow.—**American Optical Co., Southbridge, Mass.** 180B



Instrument Air Dryer

Cools compressed air at pressure, removes moisture.

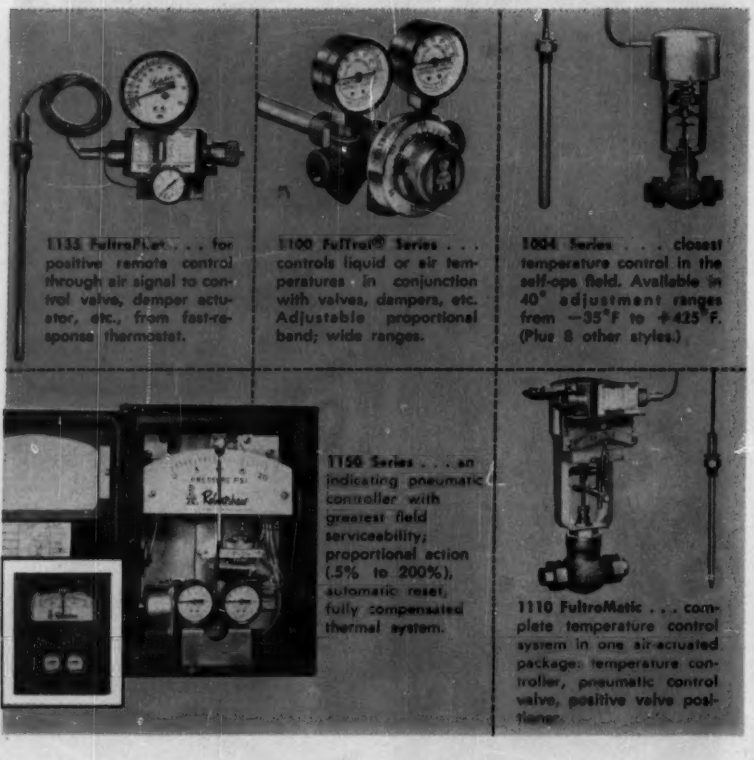
Refrigerated air dryer removes moisture and oil vapor from compressed air. Purified air is used for instrument operation service. Compressed air, dehydrated at 100 psi., has dew point as low as −5 F. when pressure is reduced for instrument service.

Model F-30 uses Freon circulation in closed-loop refrigeration to accomplish drying. Unit cools inlet air at a rate of 30 cfm. from 100 to 40 F., using refrigerating section, heat exchanger, filter, and automatic discharge mechanism.

All elements are enclosed in insulated, ASME-coded pressure vessel. Standard unit weighs 200 lb., operates on 115-v. power, has maximum operating pressure of 200 psi. Special

FROM SELF-OPS TO INDICATING CONTROLLERS . . .

Sure Control at Low Cost ...and Quality All the Way!


1133 FulTrol Set . . . for positive remote control through air signal to control valve, damper actuator, etc., from fast-response thermostat.
1100 FulTrol® Series . . . controls liquid or air temperatures in conjunction with valves, dampers, etc. Adjustable proportional band; wide ranges.
1034 Series . . . closest temperature control in the self-ops field. Available in 40° adjustment ranges from −35°F to +425°F. (Plus 8 other styles.)
1150 Series . . . an indicating pneumatic controller with greatest field serviceability; proportional action (5% to 200%), automatic reset, fully compensated thermal system.
1110 FultroMatic . . . complete temperature control system in one air-actuated package: temperature controller, pneumatic control valve, positive valve positioner.

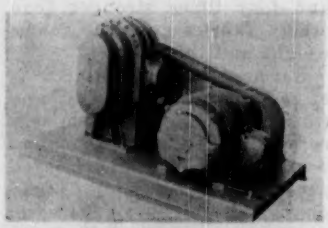
From the rugged simplicity of self-ops to the more complicated requirements of an indicating controller, Robertshaw answers your temperature control needs — efficiently and economically.

And whichever Robertshaw instrument best fits your particular job, you know there's quality all the way . . . quality of design, construction, performance.

Check the Robertshaw temperature and pressure controls for *your* needs. You'll find them shown in detail in Catalog A-NC. **Fulton Sylphon Division, Robertshaw-Fulton Controls Co., Knoxville 1, Tenn.**

Robertshaw MR. CONTROLS®

units withstand 300 psi., operate on 230-v. power.—**Hankison Corp., Canonsburg, Pa.** 181A

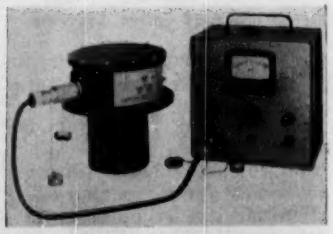


Package Blower Unit

Completely assembled and ready for installation.

A blower mounted on a single base with drive is shipped completely assembled and ready for installation. Availible with both single and double stage units, blower is positive-pressure rotary type with wide-face herringbone gears.

Suitable wherever a new or increased air supply is needed, blower comes in capacities from 1,500 cfm. at 3 psi. to 450 cfm. at 10 psi., in hp. range from ½ to 40.—**Sutorbilt Corp., Compton, Calif.** 182A



Radiation Monitor

Remote measuring system gives high-dose alarm.

Series RM-1000, radiation measuring system, measures X-ray and gamma-ray energies for ionizing dose rates from 0.5 to 1,000 Roentgens/hr. New system, battery operated with six-month life, consists of a detection chamber and electronic measuring unit. Strip chart recorder is optional.

Indicating unit may be 500 ft. from detector, which is rugged and weatherproof. An alarm

These bottles hold the key to better bag packaging!

Imagine 1500 bottles sitting on a shelf! That's what you'll find at the main St. Regis® Bag Division Laboratory in East Providence, Rhode Island.

What's inside the bottles? Hundreds of samples of solid materials – ranging from granules to powder! Each has been scientifically tested, to find solutions to bag-packing problems.

As a result of these tests, St. Regis can readily determine the flow characteristics of *your* product, new or old. And can recommend the right machine to pack it from more than 50 models.

St. Regis has been serving the chemical industry in this way since 1939 . . . has pioneered with basic and applied research in the fundamental flow behavior of dry, divided solids ever since the chemical industry first began to cope with this problem on a major scale 20 years ago.

Research engineers continually test the high and low speed, the steady and unsteady flow of solids . . . as well as the dynamics and control of packaging machinery. This constant research has led to the development of faster high-speed packaging machinery, such as the new Force Flow Packer.® It is another example of St. Regis' *Packaging-in-Depth* in action!

To find out if *your* packer is best suited to *your* operation, ask your Bag Division Packaging Engineer.

Packaging-in-depth by BAG DIVISION **St.Regis** PAPER COMPANY

FOR TOUGH FILTERING

Use

NEWARK STAINLESS STEEL FILTER CLOTH

- CORROSION RESISTANT
- NON-CONTAMINATING
- RUST PROOF
- EASY TO CLEAN
- FREE, EASY FILTRATE DISCHARGE
- EXCEPTIONALLY LONG SERVICE LIFE

Check these *operating* advantages found in Newark Stainless Steel Filter Cloth. They may suggest the solution to one of your special filtering problems or they may be the answer to your need for a backing cloth that will really stand up through tough, corrosive filtering cycles.

Newark Stainless Steel Filter Cloth is easily adapted to practically all types of filters and is available in a wide variety of weaves. When writing please give us details on your process.

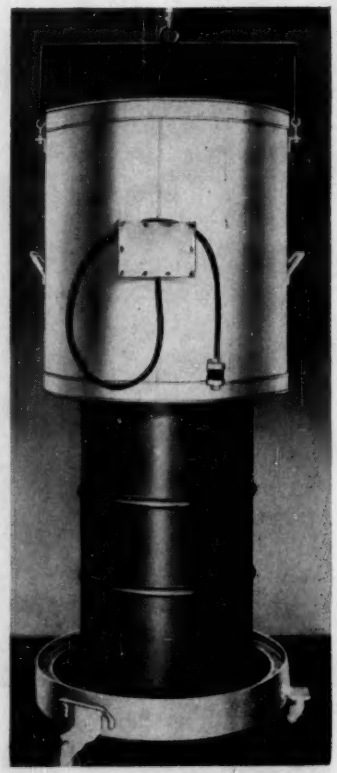
NEWARK for ACCURACY

Send for our New Catalog D.

Newark Wire Cloth COMPANY

351 VERONA AVENUE • NEWARK 4, NEW JERSEY

circuit in the electronic unit emits an audible and visible signal when radiation greater than 0.5 Roentgens/hr. hits the detector. RM-1000 system is particularly designed to monitor fall out and to give an all-clear indication as radiation decreases in contaminated areas. **—Computer Equipment Co., Los Angeles, Calif. 182B**



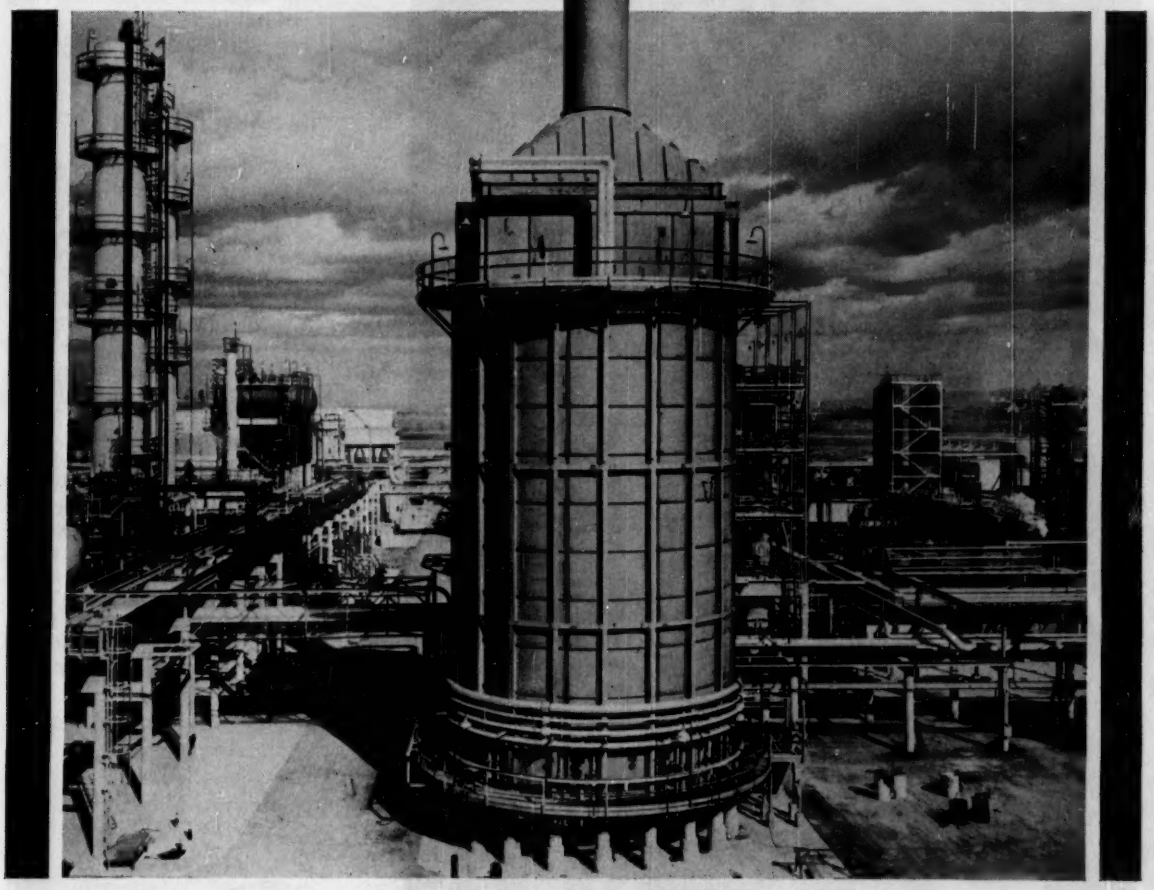
Portable Drum Heater

Covers drum completely for controlled heating.

One man, one hand control the main section of three-piece drum heater with the aid of pulleys and counter weights. Heater consists of base, cylindrical shell, and top, all made of aluminum.

Operator places drum on portable base, then lowers cylindrical section over it and puts on cover. Heating elements are close together in rugged fabrics to assure uniform heat input and prevent localized over-

Struthers Wells FIRED HEATERS



The heater above is installed in the refinery of a leading Mid-Continent oil company. Extending to a height of 150 feet, the heater is one of the largest of this type ever built.

Designed for high thermal efficiency, the heater is used on isobutane stripper reboiler service. Dual fuel burners allow the use of a wide range of fuels. Special wind boxes are provided to reduce burner noise level to a low figure.

This heater is typical of the wide range of equipment offered for standard and special requirements, including the highest commercial temperatures. Many special systems have been constructed for unusual requirements. Waste heat boilers and economizers for reclaiming heat from high temperature gases have also been supplied.

For additional information and address of your local Struthers Wells representative, see Chemical Engineering Catalog, pages 154 to 1560.

STRUTHERS WELLS CORPORATION
WARREN, PENNSYLVANIA
Plants at Warren and Titusville, Pa.

PROCESSING EQUIPMENT DIVISION
Crystallizers . . . Direct Fired Heaters . . . Evaporators . . . Heat Exchangers . . . Mixing and Blending Units . . . Quick Opening Doors . . . Special Carbon and Alloy Processing Vessels.

BOILER DIVISION
BOILERS for Power and Heat . . . High and Low Pressure . . . Water Tube . . . Fire Tube . . . Package Units

FORGE DIVISION
Crankshafts . . . Pressure Vessels . . . Hydraulic Cylinders . . . Shafting . . . Straightening and Back-up Rolls

STAINLESS

PIPE & TUBE

2" schedule 80 max.

leadership through research

UNION STEEL CORPORATION

SEAMLESS
in addition to Welded

heating. Separate thermostats in base and cylinder permit controlled temperatures to 550 F.

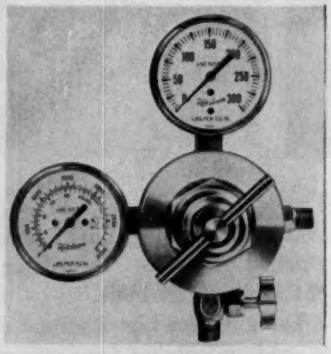
Heavy casters on the base make it possible to move the 95 lb. unit with or without drum load.—**Glas-Col Apparatus Co., Terre Haute, Ill.** **184A**

Convertible Valve

Switches from manual to control valve service.

Dead-end service valves can be upgraded to control and motor-operated valves, in new line of venturi-ball design. Conversion is made by replacing bonnet and stem with new bonnet and stem along with a yoke carrying the required top-works.

Known as P-K Paul Barstock Valve, unit has inside screw on manual valve and outside screw and yoke on automatically operated valves. Valve is available in ¼-, ⅜-, ½-, and ¾-in. sizes for pressures of 1,500 and 2,500 psi.—**General Kinetics Corp., Englewood, N. J.** **186A**



Pressure Regulator

Stainless-steel unit for handling corrosives.

Corrosive fluids and atmospheres are combatted with new stainless-steel pressure regulator, designated 640 series. Wetted parts are either Type 316 stainless or Monel while other parts are 18-8 stainless. Corrosion resistance feature is

ACCURATE METERING DIRECT IN POUNDS!

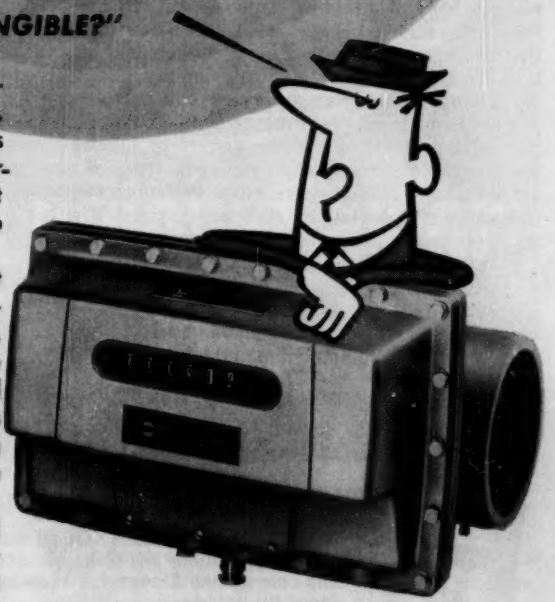
In the measurement of: Ethylene, liquid & gaseous, Propylene, liquid & gaseous, Methane, Natural Gas, Nitrogen, Freon, liquid & gaseous, Oxygen, Helium, Kerosene, Propane, Butane, Naphtha, Carbon Dioxide, liquid & gaseous.....

"ARE YOU GOING TO DETERMINE VOLUME? OR WEIGHT? WHICH IS THE MOST TANGIBLE?"

The BS&B True Mass Flowmeter solves your metering problem by giving you a direct, immediate, accurate reading in pounds. No correction factors are necessary for pressure, temperature, supercompressibility, or any other variables which affect conventional metering devices. And, there are no in-between calculations.

The fluid flows into one end of the meter, out the other; in between are the sensory and registering instruments. It's as simple, and complex, as that. But the complexity, the ingenuity, the theory are in the meter — not in the theoretical assumptions you must make, the extra recordings you must have, the calculations you must perform in order to get a delayed reading of uncertain accuracy with a conventional metering device.

The BS&B True Mass Flowmeter satisfies a need of which industry at large has been aware for many years—the need for an accurate, economical meter for the measurement of industrial liquids and gases, by metering weight—not volume.



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For Process Ion Exchange

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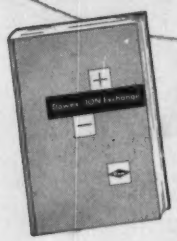

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carried through nonmetallic parts—seat and diaphragm are Teflon, seating disk and O-ring seals are Kel-F.

Regulator may be used for general service or for gases such as hydrogen sulfide, sulfur dioxide, nitric oxide, and other gases compatible with the designated internal parts. With maximum inlet pressures of 2,000 psi., delivery pressures range up to 125 psi.—**Hoke, Inc., Cresskill, N. J.** 186B

BRIEFS

Silicone O-rings made from compound TH-1057 are highly resistant to swelling caused by solvents and oils. Rings have good dry heat resistance and seal fluids up to 450 F.—**Stillman Rubber Co., Culver City, Calif.** 188A

Sensing and switching system uses ultrasonic energy for beam. Called Sonac, device consists of two sensors and control unit, will sense liquids, solids, opaque or transparent objects. Operates from —100 to 220 F. on 1-w. input.—**Delavan Mfg. Co., W. Des Moines, Iowa.** 188B

Explosion-proof hand lamp weighs only 4½ lb., is made of non-sparking materials. Guard, globe and holder assembly remove as one unit for relamping. Swivel-type hook on guard holds lamp in tight spots.—**Crouse-Hinds Co., Syracuse, N. Y.** 188C

Self-storing air hose extends from 5x9 in. coil to 20 ft. length like a telephone cord. Nylon-based Synflex hose is impervious to oils, holds 200 psi., has resusable couplings.—**Synflex Products Div., Samuel Moore & Co., Mantua, Ohio.** 188D

Emergency power and lighting unit takes over within 1/20th of a sec. after 115-v. a.c. power fails. Available in sizes up to 250 w., it operates from 6- or 12-v. storage battery which is kept at full strength with trickle charger

when normal power is on.—**American Television & Radio Co., St. Paul, Minn.** 188E

Vibrating feeder moves 75 tons/hr. when operating on level, more when sloped downward. Permanent electromagnetic drive operates on a.c. current in both suspended and base-mounted units.—**Eriez Mfg. Co., Erie, Pa.** 189A

Pneumatic conveying system handles dry, free-flowing solids by either pressure or vacuum. Unit consists of motor, blower, flexible tubes, and cyclone. Motor is either electric or gas depending on application.—**Daffin Mfg. Co., Lancaster, Pa.** 189B

Gate valve has a flexible wedge disk which makes sealing and unsealing operation easier. If valve is hot when closed, then cools, disk flexes slightly to conform to new seating position. Smaller 150-lb. valve holds 40 psi. at 1,000 F, 275 psi. at 100 F. For same temperature range, 300-lb. unit stands 85 to 720 psi.—**Crane Co., Chicago, Ill.** 189C

Equipment Cost Indexes . . .

	Dec. 1959	Mar. 1960
Industry		
Avg. of all	237.0	237.8
Process Industries		
Cement mfg.	231.1	232.4
Chemical	239.0	240.0
Clay products	224.6	225.8
Glass mfg.	225.6	226.6
Paint mfg.	228.7	229.7
Paper mfg.	230.2	231.3
Petroleum ind.	233.6	234.7
Rubber ind.	236.5	237.5
Process ind. avg.	235.4	236.3
Related Industries		
Elec. power equip.	242.1	242.8
Mining, milling	240.4	241.5
Refrigerating	267.3	268.4
Steam power	223.9	224.9

Compiled quarterly by Marshall and Stevens, Inc. of Ill., Chicago for 47 different industries. See Chem. Eng., Nov. 1947, pp 124–6 for method of obtaining index numbers; April 4, 1960, pp 149-50 for annual averages since 1913.

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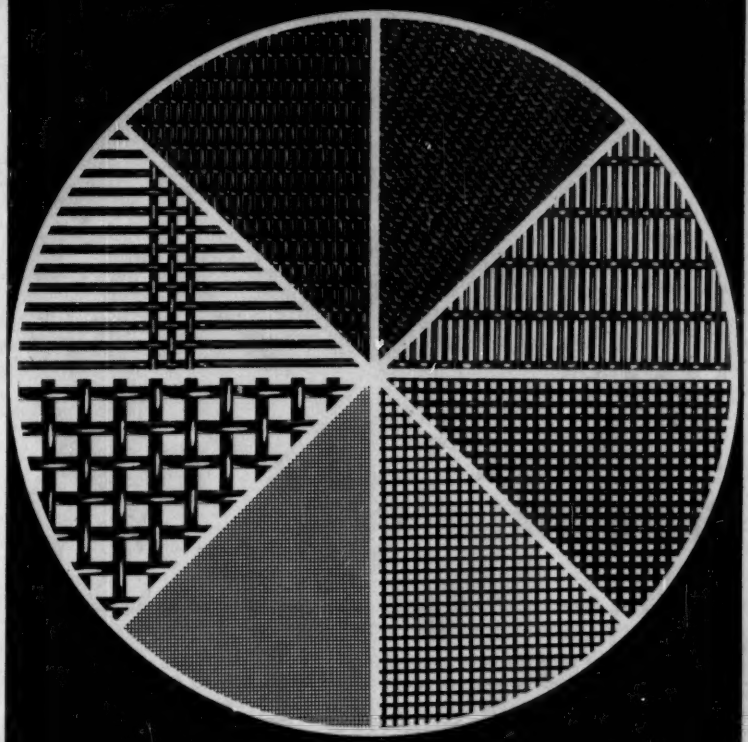

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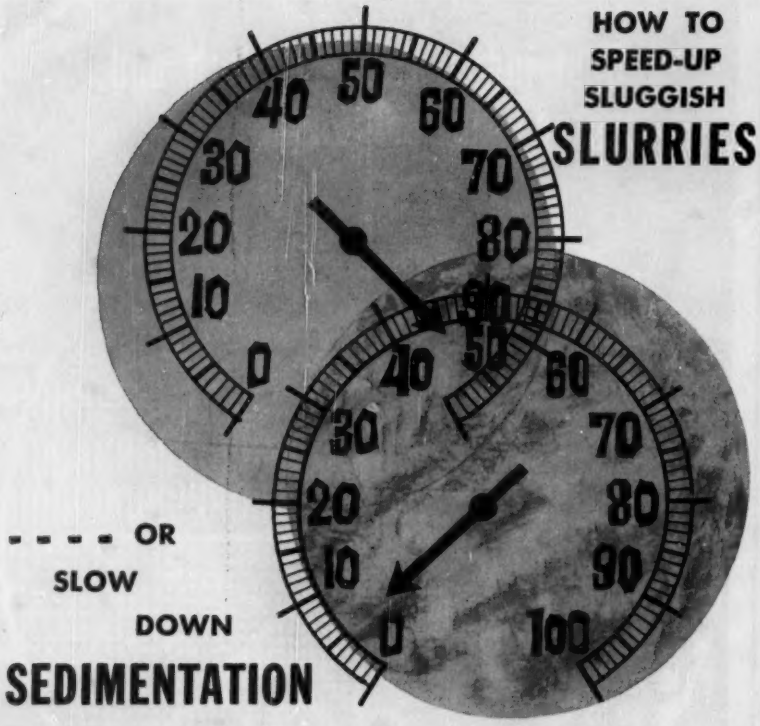

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Alphabetic Series to Systematic Subject Index. German and English. 109 pages. In wrappers $7, cloth $8.50.

A systematic subject index lists all terms required for evalution and organization of pertinent data. Individual terms are arranged in a logical classification which may be expanded to suit future requirements. The alphabetic series, supplementing the systematic subject index, facilitates incorporation of subject matter in the proper places. Classification terms in the alphabetic series have code numbers repeated in the systematic subject index, so the concept can be located within the proper group in the system. The number of terms in the alphabetic series exceeds that in the systematic index by better than 50%, because it includes synonyms and miscellaneous terms whose place within a specific group may not be readily discernible. The indexes have proved themselves in documentation work over several decades, and are applicable to computer systems.

Magnetic materials. Magnetic and electrical properties. Second supplement to System No. 59, Iron, part D. 1959. 580 pages, 308 graphs. In wrappers $77.04, cloth 78.24.

BOOKSHELF

This volume also supplements those on Cobalt, Nickel, Manganese, and Chromium. Ferromagnetics is important in electrical engineering, especially power supplies, communications and automation. Metallic and ceramic permanent magnets, including the Fe-Si alloys, are used in cores and circuit elements. In metallography, magnetic measurements help to understand the interaction between metal atoms and the atomic structure of matter in general. In accordance with the "principle of last position," the material is grouped as follows: 26 pages on iron, 121 on the alloys of iron; 11 on cobalt, 13 on Co alloys; 63 on nickel, 42 on Ni alloys; 22 on manganese alloys; 2 on chromium alloys; 121 on ferromagnetic semiconductors. A theoretical chapter precedes data on materials and reviews present concepts of the origin of ferromagnetism and the behavior of the materials concerned.

Developments of the last two decades which affect ferromagnetic elements and the Fe-Co, Fe-Ni and Co-Ni systems, the Fe-Ni-Al systems (10 pages and 126 patents) and the Fe-Si system (11 pages, 75 patents) are discussed fully. For the important ferrites group (100 pages, 184 patents) including ferrospinels and barium oxides the literature is covered through 1955; some references are even more recent. All patents issued up to June 1957 on preparation or heat treatment of magnetic materials (unless covered in "Iron," part D, supplement I) are compiled on 66 pages, including those claiming extremes in the specific resistivities of the ferromagnetic substances. The numerous systems covered by the 837 patents are listed alphabetically on 45 and 5 pages (alloys and oxides). There are numerous tables.—There are marginal headings in English, a German and an independent English subject index.

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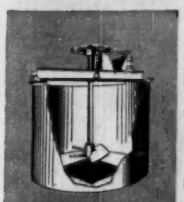

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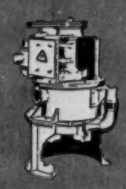

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For handling frothy liquids or coarse, sandy slurries, constant or intermittent flow. No packing gland or sealing water. Standard or stainless steel construction. Capacity to 450 g.p.m.

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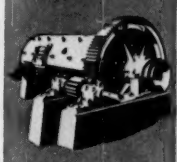
Lab and pilot scale vertical centrifugal pumps in LG3-B10



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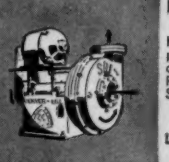

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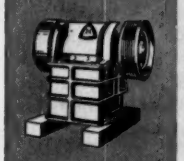

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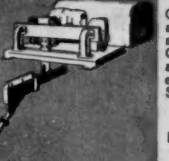

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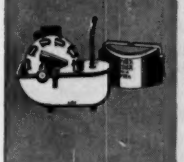

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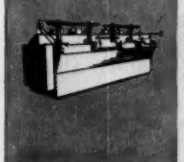

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"Intellectual let-down" — that tendency so common to many engineers to "stop learning" as soon as they acquire a sheepskin — will be completely out of style by 1999. Indeed, it is passe in today's accelerated engineering profession, because to stop learning is to stop growing: to stifle imagination, to throttle creativity, and ultimately to kill scientific progress.

The engineer who would keep pace with his own industry — especially the process industry — must determine to follow a prescribed, disciplined course of action, if he is to achieve the stature, prestige, responsibility and income to which he aspires. He must recognize that only as his engineering achievement advances will his personal well-being also increase.

There is no magic formula for the "successful engineer," but for what they are worth to your professional future, here are 14 "ground rules" for your consideration:

Set objectives for your professional and personal life, re-examine them periodically, but always work towards a goal in life.

Develop sound work habits. Earn a reputation for promptness, attention to detail, accuracy, diligence, reliability.

Continue to study your chosen field or specialty. Your learning process must never cease functioning.

Seek additional training, technically or in non-technical fields which can be of importance to future development.

Think creatively about your job, your company, technological advances and developments. Dare to think **beyond** your capacity.

Expand your capacity to discover new fields of endeavor, discriminatingly, however, so that they will have application to your objectives.

Take a genuine interest in people, their potentials, their problems. Understand, but don't condemn, their shortcomings.

Broaden your base of appreciation for other pursuits, such as sales, accounting, law, advertising. They, too, are important to your company.

Study the fundamentals of business. Learn the economics of your company, its basic philosophy, its obligations and responsibilities, its opportunities and limitations.

Seek advice and counsel from others; don't rely entirely on your own resources . . . Ask questions.

Participate actively in technical societies; keep alert to professional trends, changing concepts, new developments.

Use common sense and sound, practical judgment in evaluating everything from people to processes.

Aggressively pursue your professional and personal ambitions, but with patience and intelligence.

Learn to communicate your ideas and opinions pleasantly, clearly, concisely, aggressively to your superiors, associates, subordinates.

The development of a successful career in engineering bespeaks **constant, consistent dedication** to professional and personal principles. Perhaps these few paragraphs can serve as a guide for your own engineering future and advancement. (Footnote: for more detailed discussion of the suggestions made herein, write for your free copy of "14 Ground Rules," to WESTERN SUPPLY COMPANY, HEAT EXCHANGER DIVISION, P. O. BOX 1888, TULSA, OKLA. — and if there's a heat exchanger in your company's future, we'd like to demonstrate how these "14 ground rules" affect our heat exchangers!

TECHNICAL BOOKSHELF . . .

Cadmium, supplement Volume. System No. 33. 802 pages, 218 figures. In wrappers $121, cloth $122.

The opening 19 pages present additional data on the geochemistry of Cd and individual minerals. Next, 24 pages treat production by industrial concentration, distillation, electrolysis and combined processes. Physical properties, on 140 pages, deals with the crystallography and elucidates controversial data on polymorphism and deformation mechanisms. On 127 pages, electrochemical aspects (cells, potentials, standards, the Weston cell) are dealt with, following this there are 16 pages on Ni-Cd batteries, with references up to 1958. The electrodeposition of Cd from a variety of baths is discussed on 38 pages. The chemical reactions of the element take 21 pages, physiological effects 3 pages. Cd alloys, especially Cd-Zn alloys, their structure and preparation, are treated on 60 pages. On another 300 pages, the crystallographic properties of compounds are presented, with consideration given to lattice arrangements, polymorphism, preparation methods, and the photoconductivity of CdS, CdSe and CdTe. The last 80 pages are on addition and complex compounds of Cd with inorganic and organic neutral ligands. For convenience, a condensed empirical formula index and an alphabetic index of ligands are added. The table of contents is in German and English, as are the headings and subheadings.

Fluorine, supplement volume. System No. 5. 258 pages, 31 graphs. Cloth, $36.

The first chapter presents known information on the cosmic occurrence of F and its concentration in typical minerals, waters and biological substances. While F is more abundant in the earth's crust than Cl, there is little of it in the hydrosphere and the biosphere. Among F-bearing minerals, only fluorite is economically important. Electrolytic

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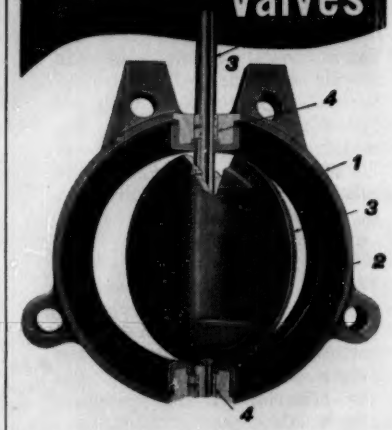

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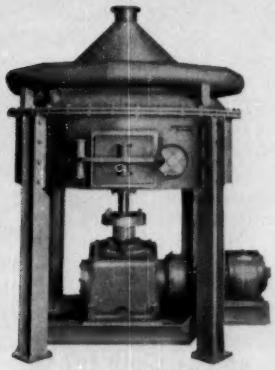
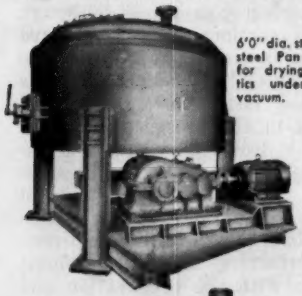
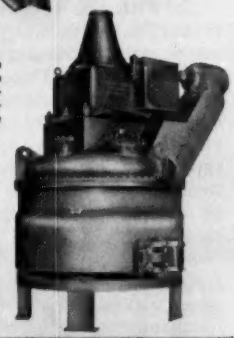


5'2" dia. stainless steel Pan Dryer with scraped and jacketed bottom. Used for drying an organic solvent from a naval stores product.



6'0" dia. stainless steel Pan Dryer for drying plastics under high vacuum.



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production of the element is treated on 15 pages. The prevalent process for making HF is covered on 12 pages, along with laboratory scale production of compounds, and the treatment of raw materials and their purification, toxicity hazards, safety requirements in handling, and economics. The physical properties of the element, of HF and other compounds are given on 43 pages. The chemical reactions take 40 pages, including uses of HF as a solvent, and the fluoridation, polymerization, condensation and cyclization of organics with HF. The analytical chapter on 24 pages treats special methods only, referring for general information to Fresenius and Jander's text. The final chapters review hydrogen compounds on 78 pages, and oxygen and nitrogen compounds on 14 and 24 pages, respectively. Again, the table of contents, headings and subheadings are in German and English.

Silicon, part B. The element. Inorganic compounds. System No. 15. 923 pages, 154 graphs. In wrappers $135.50, cloth $137.

The volume treats the chemistry and physics of the element, the hydrides (silanes), oxides, siloxanes, silanols, siloxenes; nitrogen, halogen, Se, Te, B and C compounds. The element which has some metallic characteristics and is important as a semiconductor, takes 226 pages. Based on the work of A. Stock and successors, compounds of silicon with hydrogen are discussed on 32 pages. The oxygen compounds take 376 pages. There are 11 pages on the monoxide, 19 pages on the solid state forms of SiO_2, 14 pages on their crystallography, 29 pages on the optical, 25 on the electrical, and piezoelectric behavior of quartz. The silicic acid sol takes 36 pages, the gel 83 which present processes and properties, and uses as catalyst and absorbent. Another 42 pages review SiO_2 modifications, forms and hydrates, followed by 20 pages on siloxanes, silanols and similar derivatives tending towards polymerization, and silox-

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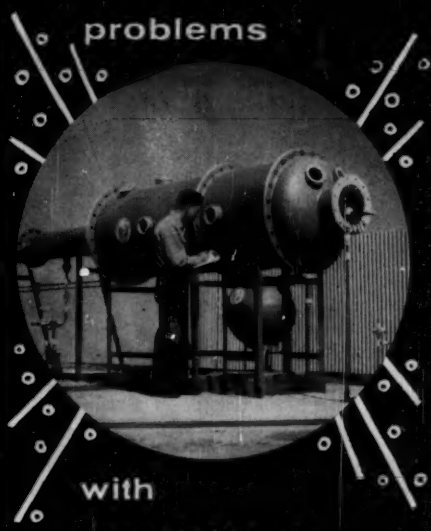

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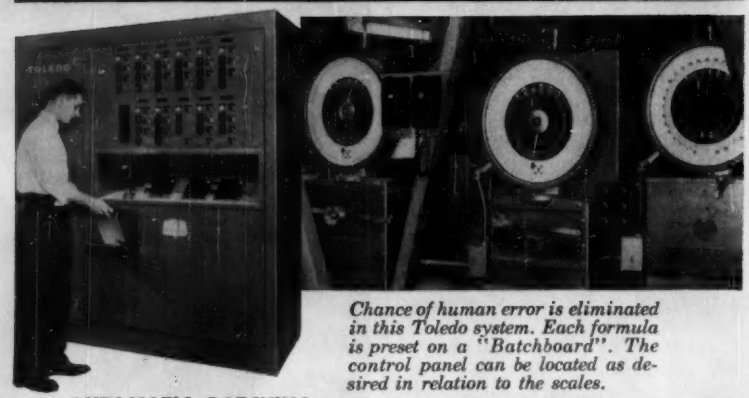

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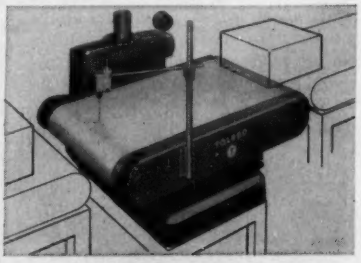

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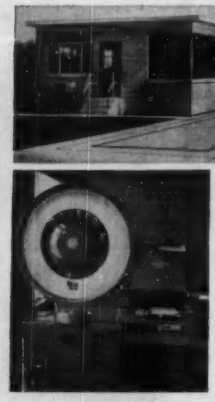

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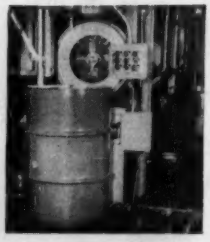

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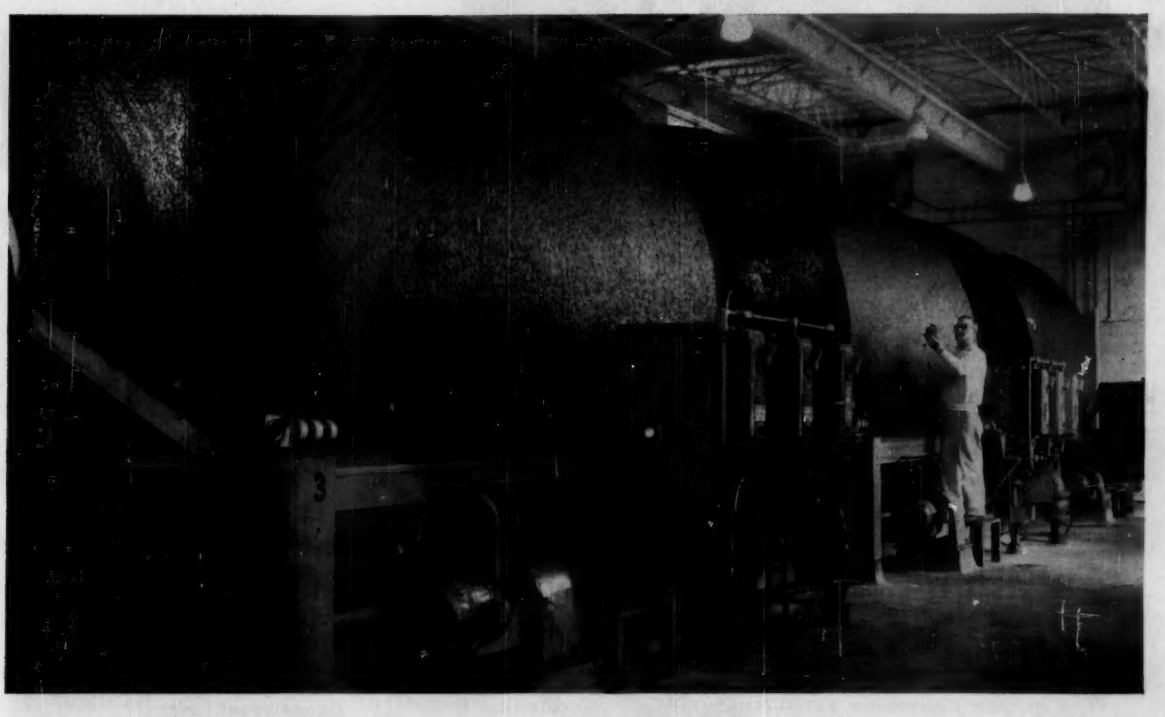
enes and their derivatives with uncommon silicon ring structures. Si-N compounds take 10 pages, silicon halides 132 pages, and sulfur compounds 13 pages. Se, Te and B compounds have 7 pages, while the carbon compounds take 103. The carbide stands out due to its chemical resistance and mechanical, thermal and electrical properties and variety of crystallographic forms. Glass electrodes and their preparation are discussed on 56 pages. An appendix presents selected literature references from 1950 to 1959.

Bilingual headings provide a German-English glossary of the chemistry of inorganic-silicon compounds.

Silicon, part C. Organosilicon compounds. System No. 15. 501 pages, 41 graphs. Cloth $67.44.

Analogies exist between hydrocarbon organics and silicon-hydrocarbon compounds, although some reactions of the two groups differ in character. Neither the hydrolysis of halogeno silanes or the instability of the Si-Si bond in the presence of water and hydroxyl ions have a counterpart in hydrocarbon chemistry. Silicon's tendency to bond with oxygen and produce chains established the basis of silicone manufacture. Most of the volume deals with the preparation and properties of silicon-hydrocarbon compounds: tetra alkyl, alkyl hydrogen, halogeno, thio, amino and alkoxy silanes, silanoles, siloxanes, and silicic acid esters. Individual compounds are treated separately, or had their characteristics summarized in tables; in all 3,000 compounds are considered.

Silicone chemistry accounts for about one-fifth of the volume: Fundamentals, problems in manufacture, significant chemical and physical properties, followed by a discussion of silicone oils, pastes, greases, resins, and uses of silicon rubber and other products. A 15-page alphabetic index and a logical classification system facilitate information on specific compounds. Glossaries, headings, subheadings are in German and English.



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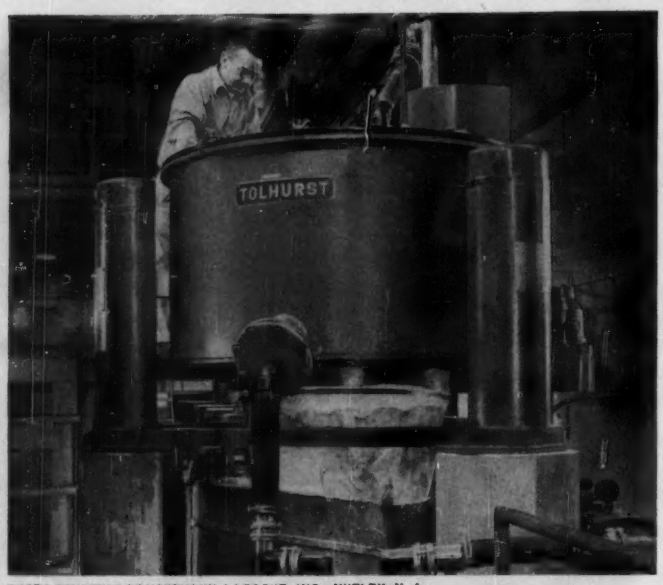

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LETTERS:

Azeotropic Rectification

Sir:

In my article on azeotropic and extractive distillation, several typographical errors showed up in the published version.

There is a glaring error in Eq. (3), and the same kind of error is repeated in the second paragraph following Eq. (3). The exponent of e in Eq. (3) should read $(P\text{-}P_1^*)V/RT$. I do not think this will create much confusion on the part of your readers, since anyone who is at all conversant with the subject will know immediately the correct form of the equation.

In Eqs. (11) and (12), the terms $x_1 = 0$ and $x_2 = 0$ should appear as subscripts.

In Eq. (15), you omitted a plus sign from the first term in the denominator. This term should read $x_1/x_2 + x_1'/x_2'$.

In Example 2, the term "Mole %" should be omitted from the columns headed V_1, V_2 and V_7. Also in this example, you erroneously referred in Fig. 10 to toluene instead of trichloroethylene.

In Example 1, you inserted the sentence, "This example, presented here for illustration purposes, is taken from Perry's 'Chemical Engineers' Handbook,' 3rd ed., pp. 653-655." This is incorrect. Example 2, not Example 1, came from Perry.

I think that in justice to me and to your readers, you should publish an explanation of how these errors occurred, since they were not my fault.

JESSE COATES
Louisiana State University
Baton Rouge, La.

▶ *We take full responsibility for these errors. Through an internal mixup, we failed to send Prof. Coates galley proofs for checking. Appropriate corrections have been made to reprints of this Report.*

We shall be happy to send a single free reprint to any reader making his request by letter. Simply address Editor, Chemical Engineering, *330 W. 42nd St., New York 36, N. Y.*—ED.

PRO & CON

C. H. CHILTON

Con: Same as Handbook

Sir:

Your May 16 issue contained an article (pp. 121-136) by Prof. Jesse Coates on the subject of azeotropic and extractive distillation.

Example 2 in Coates's article is the identical problem which I prepared and used in my contribution on azeotropic and extractive distillation in the third edition (1950) of Perry's "Chemical Engineers' Handbook," pp. 629-655.

It is apparent that both Prof. Coates and your technical editors failed to check the solution to this problem. An error was made in my original source material which was not detected until after preparation of the final proofs. It was intended that this mistake would be corrected later, on errata sheets.

It is unfortunate that Prof. Coates did not request permission to use material that was developed by me or, failing that, to properly credit the source of this material.

Furthermore, it is questionable if the scientific literature is enhanced by repetition of material previously published in such a widely used book as "Chemical Engineers' Handbook."

S. B. ZDONIK
Stone & Webster Eng. Corp.
Boston, Mass.

► *We certainly agree with Mr. Zdonik that straight repetition of Handbook material has no place in the periodical literature.*

But we find common agreement among chemical engineers that the treatment of distillation principles in the third edition of the "Chemical Engineers' Handbook" lacks coherence because of poor integration of the efforts of a number of different contributors. Whether or not Prof. Coates's attempt to reorganize and integrate this material was successful will have to be judged by our readers.

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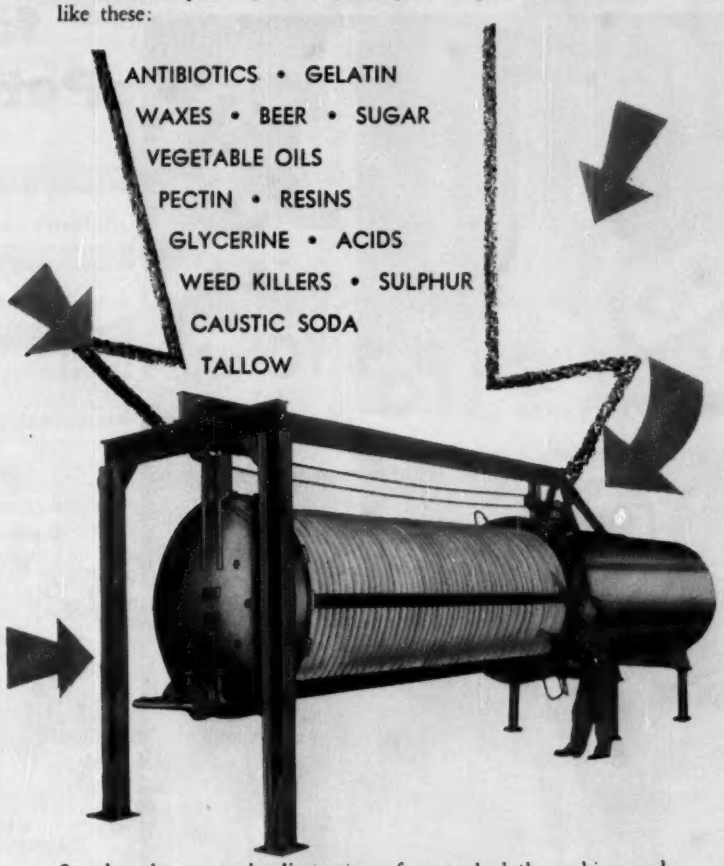

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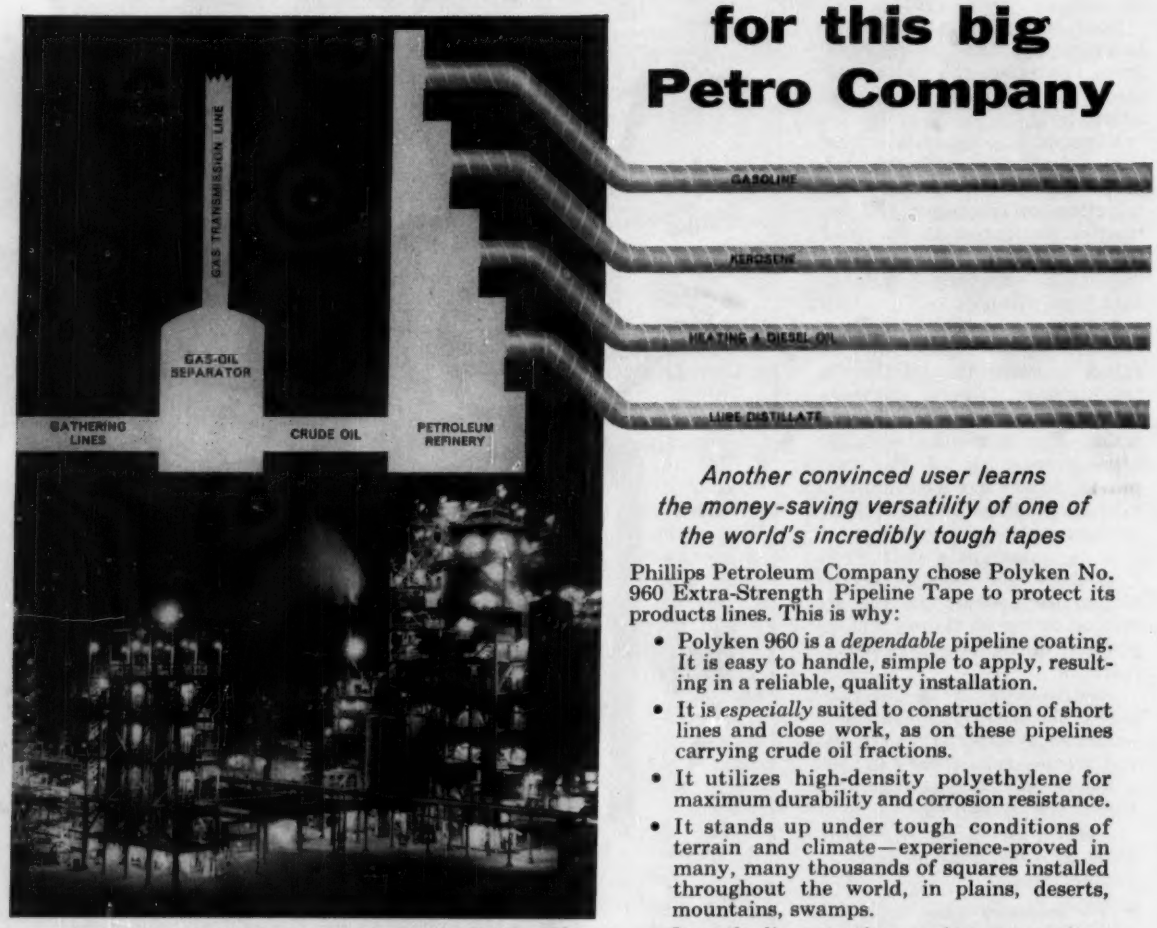

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not from handbook contributors and editors. And Prof. Coates's article did give credit for use of Example 2, but we erroneously referred to Example 1 instead.

Mr. Zdonik's corrected example occupies three typewritten pages of plate-to-plate calculations. We shall be happy to send a copy to any reader who makes such a request in writing to Editor, Chemical Engineering, *330W. 42 St., New York 36, N. Y. A copy will automatically be inserted in each reprint order.*—ED.

Pro: Fileability

Sir:

While disassembling some issues of *Chemical Engineering* to file the articles I want for reference, I ran across the offer made in your Jan. 11 issue (p. 178) regarding the index for your flowsheet series. If you still have any copies of this index available, I would certainly appreciate receiving one.

While I have appreciated and, on the whole, agreed with the changes and alterations you have made to *Chemical Engineering* in the past several years, I haven't taken the trouble until now to express my approval.

I would like to offer a suggestion. When you have two technical articles back to back, would it be possible to arrange them so that we don't have one article ending and another starting on opposite sides of the same sheet?

OTTO PFEFFERKORN
Philadelphia, Pa.

▶ *Copies of the flowsheet index are still available. This index covers the 280 flowsheets we have published since inception of this original feature. Any reader who wants a copy need only write to Editor,* Chemical Engineering, *330 W. 42nd St., New York 36, N. Y.*

As to the problem of fileability: We have gone to all lengths over the past several years in laying out the arrangement of each issue to avoid back-to-back situations in our full-page articles and departments. Only under unusual circumstances have we failed to achieve this goal.

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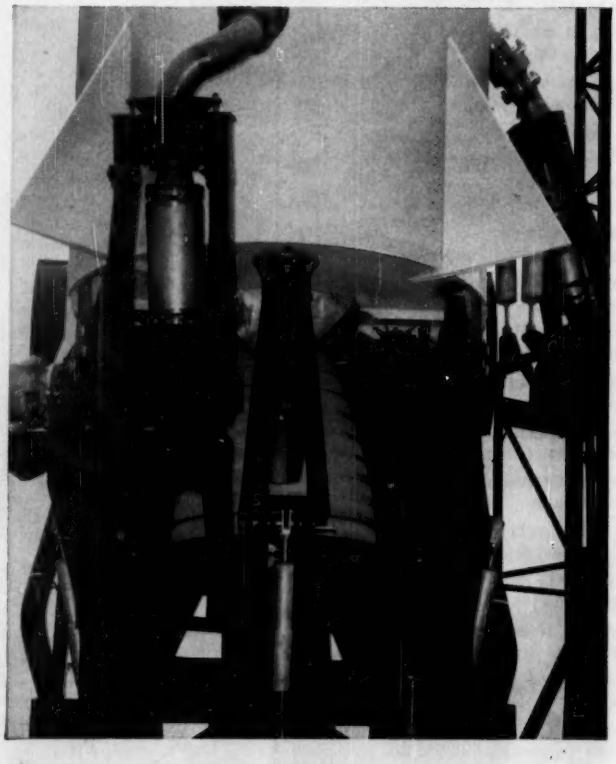

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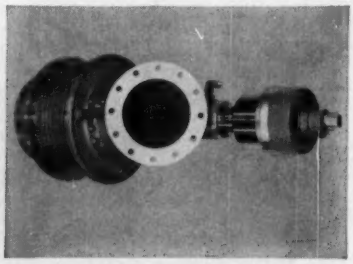

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51-52c—Trufin type H/A

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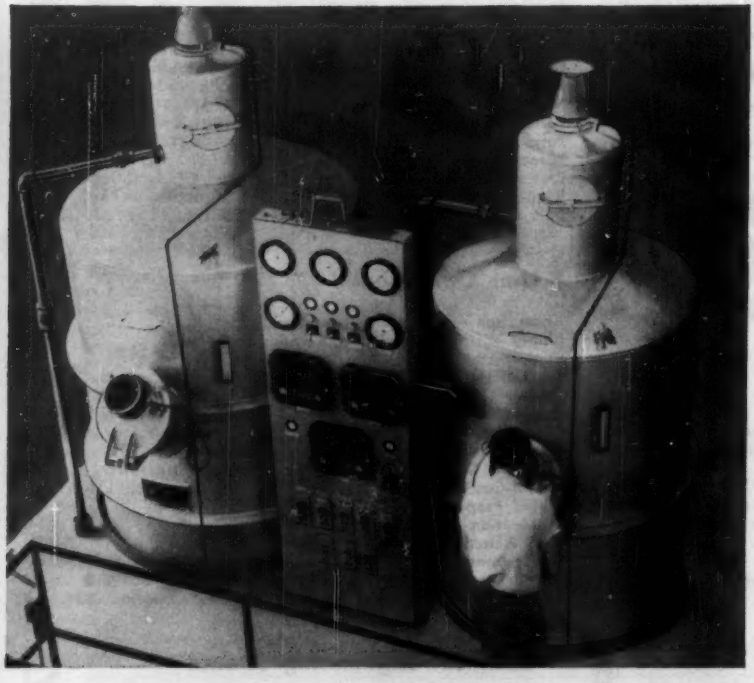

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Chemicals

Activated Aluminas.....for effective economical drying is covered in White Data Sheets & a comprehensive Gas & Liquid Dehydration Questionaire.
95 *Aluminum Co. of America

Adsorption Systems.....New illustrated booklet provides basic design data for planning both liquid & vapor phase continuous column absorption systems.
81 *Pittsburgh Chem. Co.

Algin.....The title of this bulletin, "Emulsifying, Thickening, Suspending and Stabilizing with Algin" is self-explanatory concerning its contents and slant.
204A Kelso Company

Beryllium.....Tubing made of pure beryllium and intended for use in aircraft, missiles and nuclear reactors is described in data memorandum No. 26 just published.
204B Superior Tube Co.

Borohydrides.....Qualified technical service in applying the borohydrides to your process is available. Also copies of new literature releases offered.
87 *Metal Hydrides Inc.

Bromine.....Over 100 brominated compounds produced, with new ones constantly under study. Complete information on the potentials of bromine in many applications.
67 *The Dow Chemical Co.

Butyl Rubber.....offers many outstanding properties such as damping properties, impermeability to gases and moisture, and electrical resistance. Information.
6-7 *Enjay Chemical Co.

Chemical.....Triosul ends vaporizer "clean-out" headaches & reduces contamination hazards. Additional details and Technical Bulletin I-178 are available.
177 *Monsanto Chemical Co.

LITERATURE

E. M. FLYNN

Chemical.....Easy route to totally methylolated copolymers is provided by methylolacrylamide. Drum quantities are now available from stock. Information.
24-25d *American Cyanamid Co.

Citric Acid.....is water soluble, easy handle, and non-toxic. Information about the use of Citric Acid for cleaning stainless steel contained in Bul. 102.
85 *Chas. Pfizer & Co., Inc.

Copper alloy.....Dubbed Amsulf by its maker, this 0.3% sulfer alloy is described as to machinability, conductivity, embrittlement, and other pertinent characteristics.
205A Amer. Metal Climax, Inc.

Cryogenic Gases.....A card and a wall chart give the latest data on 34 cryogenic gases. In addition, the chart gives weight and volume equivalents on the other side.
205B Air Products, Inc.

Cuprous Chloride.....is available in 100-lb. & 350-lb. drums with polyethylene bag liners. Samples, experimental quantities & full technical & price information.
69 *Allied Chem., Gen. Chem. Div.

Cyclobutanes.....The reactions of tetramethyl-1, 3-cyclobutanedione and 2,2,4,4-tetramethyl-1,3-cyclobutanediol are outlines in technical report No. N-110.
205C Eastman Chemical Products, Inc.

Dye.....New Calco Oil Red ZMQ dye for the thermoplastic market & unexcelled for tail-lights & other signalling devices, indoors or out. Additional information.
24-25a *American Cyanamid Co.

Epoxy-tar coating.....Most economical coatings for different systems and the selection of these coatings is explained industry by industry in a color folder.
205D Carboline Company

Ethyl Alcohol.....150 hard-bound, full-color pages cover tables, texts, and charts on commercial data of pure ethanol, denatured ethanol, and proprietary solvents.
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POLYCARBONATE RESIN BLENDED IN STAINLESS STEEL MIXER

Uniform blending of polycarbonate resin at the General Electric Company's Chemical Development Department plant in Pittsfield, Mass., is being accomplished in a special stainless steel 50 cubic foot vertical mixer. The 10′ 10¾″ high, 60″ diameter vertical mixer is jacketed for 14.7 psig steam pressure.

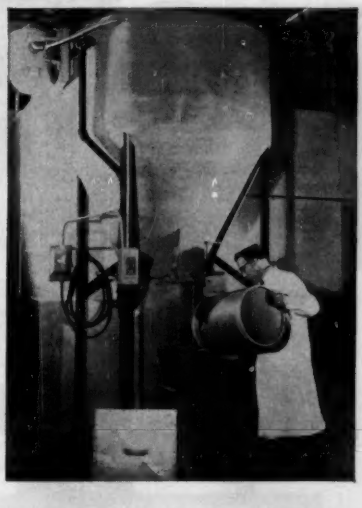
The product to be blended is trade named, "Lexan." It is a special polycarbonate resin molding compound developed by the General Electric Company to provide unusual toughness and heat stability. The mixer's job is to blend this resin while in ⅛″ chopped rod pellet form just prior to packaging.

In designing the mixer, four major problems had to be overcome. The material had to be kept warm during processing; floor space was at a premium; excessive attrition had to be avoided; and it was desired to feed the mixer from the ground floor.

The use of a steam jacket on the mixer solved the problem of keeping the material warm during processing. The selection of the Sprout-Waldron vertical mixer design took care of the floor space requirements. This 50 cubic foot capacity mixer, including the table height loading unit requires less than 15 square feet of space.

Tests were conducted to find the optimum motor speed to assure thorough blending with a minimum of attrition . . . and ground floor feeding was achieved by the design of the mixer which receives its support from four vertical legs attached to the sides of the cylinder. The hopper is centered just about table top level for convenient feeding. The forced feed-in screw and elevating section below the mixing cone offers maximum efficiency.

For more information, write for Bulletin 192.



Stainless steel jacketed vertical mixer being fed through table high hopper at General Electric Company's Chemical Development Department in Pittsfield, Massachusetts.

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PRACTICAL PNEUMATIC CONVEYOR DESIGN

A technical article by the Chief Engineer of our Materials Handling Division. It tells how to select, operate and maintain pneumatic systems for transporting dry, bulk materials. Positive, negative and combination systems are illustrated and described. Ask for Bulletin I-28.

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LITERATURE . . .

Fifth group carbides.....and their alloys with high-carbon steel is discussed in this English reprint from the Planseeberichte fur Pulvermetallurgie.
206A Chromalloy Corporation

Filter Fabrics.....Complete specifications on Orlon, Nylon, Dynel, Verel, and Polypropylene are available on request. Also fabric samples.
206B *United States Rubber, Textile Div.

Filler Materials.....Dicalites offer tremendous surface area & porosity, great bulk in relation to weight, high absorptiveness, & structural reinforcements in many uses.
28-29 *Great Lakes Carbon Corp.

Fluorocarbon Resin.....Details on properties & performance of Teflon in the new bulletin on "Lined Pipe" & general information in booklet "Designing with Teflon".
73 *E. I. du Pont de Nemours & Co.

Fluorocarbon Resins.....Fluoroflex-T for corrosive piping problems & piping components in a complete range of sizes to fit any flow process or process path. Bul.
14-15a *Resistoflex Corp.

Furfuryl Alcohol Resins.....are infusible, insolubie polymers when cured. Have low porosity. Information about uses, physical data & chemistry in Bulletin 205.
83 *The Quaker Oats Co.

Lubricant.....Not only is this lubricant described (in Bulletin 126B), but a small tube containing a sample of the new ulti-purpose grease is also included.
206C The Alpha-Molykote Corp.

Lubrication.....New booklet graphically illustrates a comprehensive lubrication program. Written for plant managers & maintenance supervisors.
206D Mobil

Maintenance Coatings.....Carboline coatings are higher in solids content, which produces greater film build-up & requires fewer coats. Maintenance Chart #5.
206 *Carboline Co.

Microcrystalline waxes.....As part of a 25th anniversary commemorative booklet, the complete line of waxes along with properties and specifications is listed.
206E Bareco Wax Co.

Modified Cellulose.....New product Cyanocel offers, flexibility, physical strength and transparency combined with outstanding electrical properties.
24-25c *American Cyanamid Co.

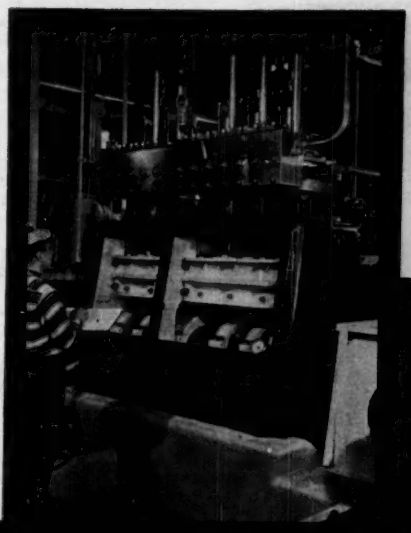
Pimelic Acid.....the seven carbon straight chain dibasic acid is now available. Booklet lists complete properties and potential uses. Send for your copy.
24-25e *American Cyanamid Co.

Plastic.....Kel-F Brand Plastic is ideally suited for many uses in the field of missiles, rockets & aircraft because it is chemically inert, thermally stable, etc.
200 *Minnesota Mining & Mfg. Co.

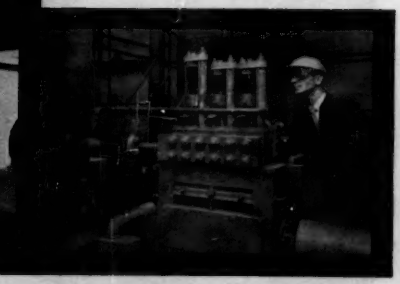
Plastic, Reinforced.....Very striking statistics on strength-to-weight ratios and fatigue strengths form the basis of this folder on brand-name "Scotchply" plastic.
206F Minn. Mining and Mfg. Co.

*From advertisement, this issue

WHAT'S YOUR SPECIAL PROBLEM IN PUMPING?



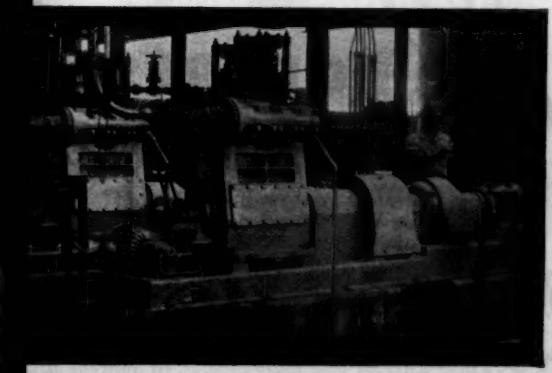
Special nylon ball valve and stainless steel fluid end handle silica gel at 1800 psi.

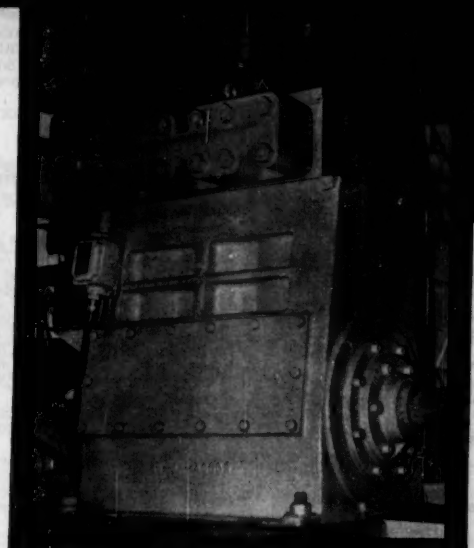


Here, Aldrich pumps continuously control the flow of liquid ammonia at 3700 psi.

This Aldrich pump handles highly corrosive chemicals—both alkaline and acidic.

Aldrich pumps with nickel alloy fluid end pump 50% caustic soda solution at 400 psi.





To handle, alternately, caustic and brine, at 3000 psi, this Aldrich Triplex pump has entire fluid end of Monel.

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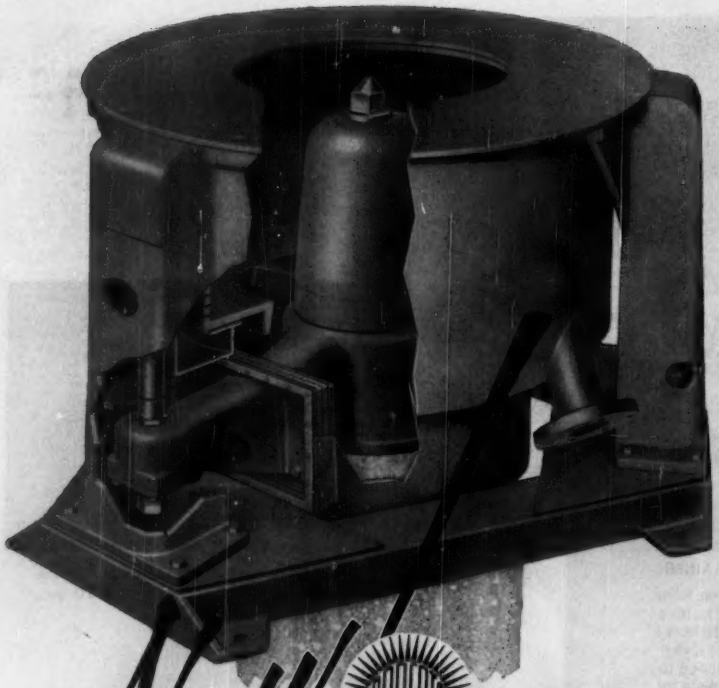
All pump companies sell pumps. And all have their share of pumping problems. At Aldrich, our most important stock in trade is our ability to solve the rough pumping problems of the process industries. We've had over 50 years of working with chemicals and chemical processes. We know the problems of pump wear; of temperature, corrosion, viscosity; and your need for sustained pump operation. We study all the factors in your problem, in depth . . . and come up with a *better* answer, not merely *an* answer. For information on capacities, pressures and sizes, see our insert in *Chemical Engineering Catalog* or write for reprint (Data Sheet 100). ALDRICH PUMP COMPANY, 3 Gordon Street, Allentown, Penna.

The tough pumping problems go to ALDRICH



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Features . . . Stationary Curb! With rigid feed, wash, effluent, and solids-discharge connections. No vibration damage to curb mounted accessories. Extends bearing life by reducing bearing loads. Increases personnel safety. Provides rapid drainage, more effluent capacity.

Features . . . Direct Coupled Hydraulic Motor! No belts. Compact. Light weight. Provides power for exclusive, slow speed, reverse discharging. Provides adjustable loading speed and adjustable top speed. Hydraulic braking (even at power failure). No brake linings to wear. Constant horsepower drive reduces peak electric loads.

Features . . . Oversize Anti-friction Bearings! Basket spindle bearing housing is air purged. This feature, designed to protect bearings from damaging effects of process material environment, also provides a convenient means for introducing controlled atmosphere within the basket. Can be grease lubricated while in operation. No-belt design — no belt-pull-loading on the bearings.

2905

Investigate its potential in relation to your operation. We will welcome the opportunity to co-operate with you.

ROBERTS STEVENS

The WESTERN STATES MACHINE COMPANY

1700 Fairgrove Avenue

HAMILTON, OHIO, U.S.A.

LITERATURE . . .

Polyethylene.....The effect of melt index and density upon the processing and performance of injection and blow-molded polyethylene is the booklet's subject.
208A Monsanto Chem. Co.

Polyvinyl Chloride.....The uses of rigid polyvinyl chloride electrical conduit along with test results, corrosion resistance charts, and specifications are listed.
208B Kraloy Plastic Pipe Co.

Polyvinylpyrrolicone.....called PVP for obvious reasons, is described as to its physico-chemical properties and its high physiological compatability in a 24-page color booklet.
208C Antara Chemicals

Resin.....Epon resin solutions come to you ready-to-use, with the solvent and solids content standardized. Can be pumped with ordinary equipment. Information.
Cover *Shell Chemical Co.

Stabilizer.....Going by the name of Attagel 30, this colloidal grade of attapulgite is intended as an agent of suspension for plant nutrients in water.
208D Minerals and Chem. Corp. of Amer.

Textile Chemical.....Cyana Permel Plush finish offers spot & stain resistance; wrinkle resistance; choice of hand-crisp to soft, etc. Additional information on request.
24-25b *American Cyanamid Co.

Urethane Coatings.....Described as a balanced series, this folder contains a chart which shows a series of 12 coatings with their composition and properties.
208E B. B. Chemical Co.

Urethane Finishes.....These coatings for wood are set by a chemical reaction instigated by the addition of a catlyst. Bulletin # 3-60 describes their applications.
208E B. B. Chemical Co.

Xylene.....Its purity is evident in its consistently high KB value, indicative also of its high solvency for paints, inks & other products. By barge, tank car, etc.
57 *Delhi-Taylor Oil Corp.

Construction Materials

Alloy.....Monel alloy is free from chloride ion stress-corrosion cracking. Information on the engineering properties of Monel alloys are available.
79 *International Nickel Co., Inc.

Aluminum products.....A complete buyers' guide lists the complete stock in addition to federal specifications, analyses, properties, tolerances, etc., in a 20-page booklet.
208F Reynolds Aluminum Co.

Coating Systems.....The Chemical Corrosion Data File includes a survey of corrosion problems in the Chemical Industry and a coating selector guide.
10-11 *Pittsburgh Coke & Chemical Co.

Coatings.....40 completely different products, each formulated to give maximum corrosion protection for specific applications. Technical data available.
167 *Amercoat Corp.

* From Advertisement, this issue

SPLIT-EYELET CONNECTORS

For faster, easier connection of spray nozzles, branch lines and equipment to piping and tubing carrying liquids, gases or air up to 250 psi. Write for Bulletin 93.

FOR BETTER PERFORMANCE

SPRAY NOZZLE ACCESSORIES

ADJUSTABLE JOINTS

For easy, exact adjustment of spray direction. Made in size for ¼" to 2½" pipe in brass, steel and stainless steel. Write for Bulletin 97.

. . . EASIER INSTALLATION

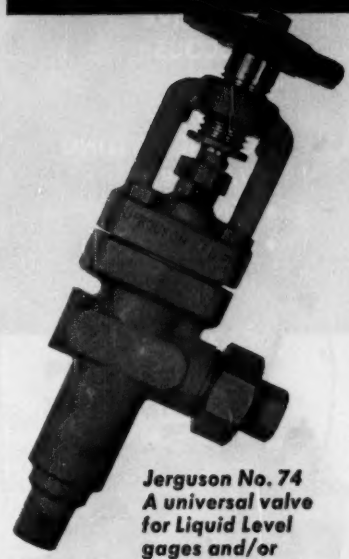
LINE STRAINERS

Special non-collapsing screen design for pressures up to 125 psi, for all pipe lines from ¼" to 6" size. Also high pressure strainers for up to 5,000 psi service. Write for Bulletin 94.

FOR COMPLETE SPRAY NOZZLE INFORMATION WRITE FOR CATALOG 24

SPRAYING SYSTEMS CO.
3275 RANDOLPH STREET • BELLWOOD, ILL.

Here is a NEW Jerguson ALL-PURPOSE ANGLE VALVE



Jerguson No. 74 A universal valve for Liquid Level gages and/or Instrument Piping and General Use

This unique New Angle Valve has unusual advantages. A universal valve, ideal for liquid level gages . . . simply add our pipe plug with integral bleed (No. 74G) for the ideal valve for instrument piping and general use.

Combines Advantages of single-piece forged body and bonnet flange, simplified OS&Y bonnet and reciprocating stem in one valve.

Forged yoke supports stem away from valve body; separate forged gland-follower bears on packing, independent of yoke. Stem thread outside, not affected by temperature or liquid. Stem works freely, no chance of freezing.

Reciprocating Backseating Stem: Works in to-and-fro motion with no rotating action; gives perfect seating, eliminates wear from galling. Backseating eliminates packing contamination from liquid; can be repacked under pressure. Teflon seating available.

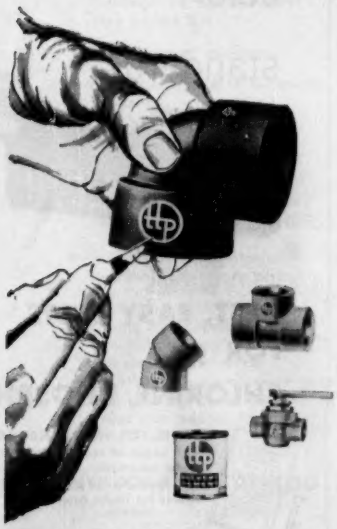
Write for catalog sheet on Jerguson No. 74 Valve.

JERGUSON

Gages and Valves for the Observation of Liquids and Levels

JERGUSON GAGE & VALVE COMPANY
100 Adams Street, Burlington, Mass.
Offices in Major Cities
Jerguson Tress Gage & Valve Co., Ltd., London, Eng.
Pétrole Service, Paris, France

Reduces piping costs ...stops corrosion



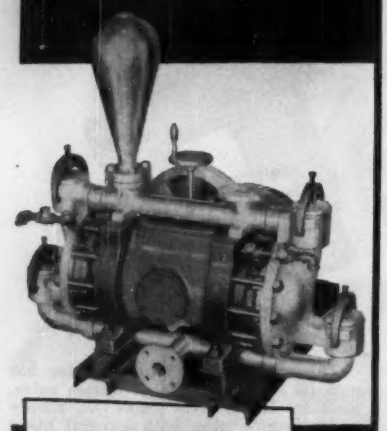
Plants, large and small, are switching to unplasticized polyvinyl chloride (UPVC) piping for corrosive services to make these important savings in first costs and in operating costs: UPVC piping materials cost substantially less than metals, alloys or lined material commonly used in the same services. It can be erected easily and quickly. Widely used socket type joint can be made in about a minute with solvent cement and a brush. UPVC piping is easy to handle...weighs less. It does not have to be painted. It stops piping corrosion and galvanic action.

The tlp* line of injection molded UPVC fittings, flanges, valves, solvent cement and thread lubricant is available nearby from your Tube Turns Plastics' Distributor. He can supply *all* your needs on one order and can help you with design and installation data. Write us for the complete line catalog, Bulletin 119. TUBE TURNS PLASTICS, INC., Dept. CE-7, 2929 Magazine Street, Louisville 11, Kentucky.

*"tlp" is a T.M. Reg. U.S. Pat. Off.

for those
hard-to-handle
fluids

- CORROSIVE
- ABRASIVE
- VISCOUS
- THICK
- HEAVY
- QUICK SETTLING
- VALUABLE
- SENSITIVE
- HAZARDOUS



SHRIVER
DIAPHRAGM
PUMP

- LOW OPERATING COST
- LOW MAINTENANCE COST
- LONGER SERVICE LIFE
- EASY TO CLEAN

Thousands of Shriver pumps handling materials that clog or wear out other pumps all too quickly have proved their amazing service economy record. It will pay you to get Bulletin 148.

T. SHRIVER & CO., Inc.
802 Hamilton St., Harrison, N. J.

LITERATURE . . .

Epoxy Insulation System.....EPA-Seal offers unexcellent protection for vulnerable motor coils. Further details are contained in new Bulletin PB-6000-12.
44-45 *Elliott Co.

Filter Cloth, Stainless Steel.....is easily adapted to practically all types of filters & is available in a wide variety of weave. New Catalog D is offered.
185 *Newark Wire Cloth Co.

Fused Quartz.....Vitreosil is available in many types and sizes. Also fabricated to your special needs. Complete, illustrated catalog is offered.
R219 *Thermal American Fused Quartz

Gasket Material.....Booklet describes "Armalon" felts & includes data on characteristics, detailed list of specific applications, & information on sizes & thicknesses.
55 *E. I. Du Pont

Insulation.....Snap-On is the one piece pipe insulation molded of fine glass fibers. Available plain or with a variety of jackets in sizes from copper tubing to 36".
169 *Gustin-Bacon Mfg. Co.

Insulation.....Styrofoam insulation resists penetration of water & water vapor, Styrofoam cannot rot nor deteriorate & is lightweight. Information.
234 *The Dow Chemical Co.

Insulation Accessory Materials..... Each accessory selected to function perfectly with cellular glass insulation. A set of PC Accessory Material Data Sheets is offered.
53 *Pittsburgh Corning Corp.

Metal Medium.....Neva-Clog has a smooth, non-porous surface; resists abrasion; does not clog, blind or corrode. Additional information in Bul. 582.
L215 *Multi-Metal Wire Cloth Co., Inc.

PVC Rigid Conduit.....is non-magnetic, non-sparking & won't support combustion. New brochure gives complete information and installation directions.
212 *Kraloy Plastic Pipe Co.

Packing Rings & Piston Cups.....Information on these self-sealing, self-adjusting rings & cups offered. Folder on Teflon-impregnated asbestos Vee-Flex rings & piston cups.
216 *Raybestos-Manhattan, Inc.

Piping Materials.....UPVC piping materials can be erected easily and quickly. Does not have to be painted. It stops piping corrosion & galvanic action. Bul. 119.
BL209 *Tube Turns Plastics, Inc.

Protective Coatings.....Polyken 960 is a dependable pipeline coating. Easy to handle, simple to apply, & its cathodic protection requirements are low. Details on request.
198 *The Kendall Co.

Rupture Disc.....The CPV unit sizes range from 1" to 24" with rupture pressure ranging from 4 to 850 lbs. PSIG at 72 F. New complete catalog is offered.
L218 *Fike Metal Products Corp.

Silicon Carbide Refractories.....properties include; high thermal conductivity, abrasion resistance, high temperature strength, corrosion resistance, etc.
30-51 *Harbison Walker Refractories Co.

* From Advertisement, this issue

You
make
test
after test
after test
with
complete
accuracy
because
TAYLOR
COMPARATORS
have
guaranteed
non-fading
color
standards

FAST, EASY TESTS FOR pH, CHLORINE, PHOSPHATE

WRITE FOR FREE HANDBOOK
101 pages of technical data and useful information. Gives theory and application of pH control. Describes full Taylor line.

W. A. TAYLOR AND CO.
414 STEVENSON LANE • BALTIMORE 4, MD

The Company that cares enough to give you the best!

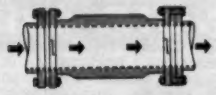
Massco-Grigsby

PINCH VALVES

RUBBER, NEOPRENE for Corrosion and Abrasion

- 1" to 14" inside diameter.
- Pressures to 150 psi.
- Temperatures to 200° F.
- Patented "hinged" sleeve. Recesses serve as "hinges" during compression; reduce strain and permit tight closing.

- Cannot leak or stick.
- No working parts in contact with pulp or liquid; no packing glands.



- Unobstructed flow eliminates high friction loss.
- Remote control available.
- Can be equipped for automatic regulation.

- Split flanges and patented Flex Seal ends assure perfect seal.
- Closing mechanisms... manual handwheel; handwheel with chain and sprocket reduction unit; electric worm gear motor reducer; chain operated torque arm reducer; hydraulic; air-hydraulic.

WRITE FOR NEW CATALOG...

Manufacturing Division

MINE AND SMELTER SUPPLY CO.

3800 RACE STREET • DENVER, COLORADO
OFFICES AND AGENTS IN PRINCIPAL CITIES

LITERATURE . . .

Stainless Steel.....New booklet "Design and Allegheny Stainless" is illustrated with hand-picked examples of good design in the gleaming metal. Outline of types, etc.
131 *Allegheny Ludlum Steel Corp.

Wire Cloth & Screen.....to help produce a better, more uniform product. Immediate shipment from stock on most weaves and sizes. Condensed Screen Catalog.
189 *Ludlow-Saylor Wire Cloth Co.

Electrical & Mechanical

Lighting Fixtures.....Slotted reflectors are white enamel finish inside & out. Information on all lighting fixtures equipped with the new slotted reflectors.
62 *Crouse-Hinds

Motor.....Applications of a Guardistor motor to your requirements and a copy of Questions and Answers About . . . Guardistor (B-7876) are available.
18-19 *Westinghouse Electric Corp.

Motors.....Flexitorq d-c motors are available in sizes from 1 to 400 hp in various enclosures. Additional information in Bulletins 3150 & 3200.
137 *The Louis Allis Co.

Seal.....New Grayloc seal eliminates leaks. Practical where leakage is a problem, regardless of high or low pressure. Works in most flange applications.
178 *Gray Tool Co.

Turbines, Axial-Flow Impulse..... built with one, two or three rows of high-grade stainless steel blading. Available in designs for moderate & high steam pressure. Bul. S-143.
108c *The Terry Steam Turbine Co.

Turbines, Multi-Stage.....designed for non-condensing, condensing, mixed pressure or bleeder operation. Sizes up to 5000 HP, speeds up to 10,000 RPM. Bul. S-146.
108a *The Terry Steam Turbine Co.

Turbines, Solid-Wheel.....are available in vertical designs depending on frame size. Capacities from 5 to 2,000 HP. Described in Bulletin S-116.
108b *The Terry Steam Turbine Co.

Quick Couplers.....Kamloks are available from stock in bronze, aluminum, stainless steel, monel and semi-steel from ⅛" through 6" sizes. Handbook F-10R.
BR218 *OPW-Jordan

Handling & Packaging

Automatic Batching.....Several types of remote-control batching systems for today's needs, including punch card, "Formulaplug" and digital scanner covered in Bul. 2964.
194a *Toledo Scale Corp.

Automatic Checkweighers.....Models to provide continuous 100% in-line checkweighing of items from a few ounces to 200 lbs. Handle sacks, cartons, etc. Bul. 2968.
194b *Toledo Scale Corp.

* From Advertisement, this issue

Dependable, Low Cost

• GRINDING
• MIXING
• BLENDING

abbé
ENGINEERING
PEBBLE and BALL MILLS

NO SEPARATE MIXING

INCREASED CAPACITY

For quality-controlled, low cost dry or wet grinding, mixing or blending on a production basis, you'll find Abbé-Engineered Pebble and Ball Mills unequaled in production speed, operating cost and service life.

Abbé-Engineered Pebble and Ball Mills are available in a complete range of sizes from 40 to 13,000-lb. capacities.

Ask for quotation on Abbé "Non-Contaminating" Rubber-Lined Pebble Mills. Write for Abbé Mill Catalog No. 77

abbé ENGINEERING CO.
620F GRAYBAR BLDG., NEW YORK 17, N. Y.
Designers and Manufacturers of
Ball, Pebble and Jar Mills • Pulverizers
Sifters • Cutters • Mixers

KRALOY PVC RIGID CONDUIT before encasement in concrete slab. Its mirror-smooth interior walls make fishing easier.

ABSOLUTELY NO CORROSION, LOW COST INSTALLATION, WITH KRALOY PVC RIGID CONDUIT

Continuing research and laboratory quality control – plus U/L listing*– have made KRALOY PVC RIGID CONDUIT a major advancement in electrical raceways. Not affected by rust, rot, pitting or soil electrolysis, KRALOY PVC CONDUIT has properties that make it the *preferred* conduit. Precision-extruded, corrosion-proof KRALOY is non-magnetic, non-sparking, *won't support combustion.* Its mirror-smooth walls make fishing easier – and its amazing light weight (approximately 1/6 the weight of steel, 1/2 that of aluminum) makes its easier to carry, handle and install. KRALOY PVC CONDUIT needs no threading, can be cut easily and joined by a simple solvent weld. It never needs painting or coating. And contractors report that installation costs are cut as much as 20% with KRALOY PVC on the job. If you'll consider KRALOY'S trouble-free characteristics and the money that can be saved in installation, you'll specify KRALOY PVC CONDUIT on your next job. Send the coupon today for the full story on KRALOY – the *first* and *only* PVC conduit with U/L listing*!

NOTE THESE WEIGHT COMPARISONS (LBS.)

Trade Size	½"	1"	2"	3"	4"	5"	6"
KRALOY PVC	**15.0**	**29.0**	**63.0**	**131.0**	**167.0**	**253.0**	**326.0**
ALUMINUM	27.4	53.0	115.7	238.9	340.0	465.4	612.9
STEEL	79.0	153.0	334.0	690.0	982.0	1334.0	1771.0

Kraloy Plastic Pipe Co., Inc., Dept. Che-7
402 West Central Avenue, Santa Ana, Calif.

Gentlemen: Please send me your new Brochure on KRALOY PVC CONDUIT which gives complete information and installation directions.

Name_____

Address_____

City_____ Zone____ State_____

KRALOY PVC CONDUIT is sold only through wholesale electrical supply houses.

NO CONDUIT REPLACES **KRALOY**

*For direct underground burial or encased in concrete.

LITERATURE . . .

Bag Closing Equipment.....Automatic bag closer sews at rate of 30 feet per minute. Details & complete catalog-file of bag closing equipment available.
TL213 *Dave Fischbein Co.

Caustic Soda Bags.....approved for both rail and truck shipment in 50 and 100 lb. sizes. Offer easier, cheaper disposal. Complete details available.
101 *Bemis Bros. Bag Co.

Chemical Containers.....Hackney chemical containers are built of types 304 & 316 stainless steel. Hold approximately 15½ gallons of liquid. Details.
13 *Pressed Steel Tank Co.

Conveying Guide.....The 12-pg. conveying guide discusses types of systems, illustrates & diagrams high & low density arrangements & show equipment. Bul. M-58.
170a *The Day Co.

Conveyor, Pneumatic.....Bul. I-28 tells how to select, operate & maintain systems for transporting dry, bulk materials. Includes positive, negative & combinations.
205b *Sprout, Waldron & Co.

Conveyor Screws.....Quik-Link lets you remove a single section without disturbing other components. Full facts on this & other conveyor components in Book 2989.
47 *Link-Belt Co.

Load Cell Scales.....The advantages of load cell operation are available in . . . axle load scales . . . motor truck scales . . . crane scales . . . hopper scales, etc. Bul. 2970.
194c *Toledo Scale Corp.

Materials Handling.....A wide range of Fuller systems & equipment in the field of pneumatic handling. Complete details on methods for your particular requirement.
8-9 *Fuller Co.

Storage Tanks.....A 12 pg. bulletin describes horizontal & vertical storage tanks. Filled with photos of various installations plus description of auxiliary equipment.
170b *The Day Co.

Sub-Surface Filler.....automatically eliminates foaming and controls drum filling. Provides faster, more accurate filling. Additional information in Bul. 9030.
194d *Toledo Scale Corp.

Heating & Cooling

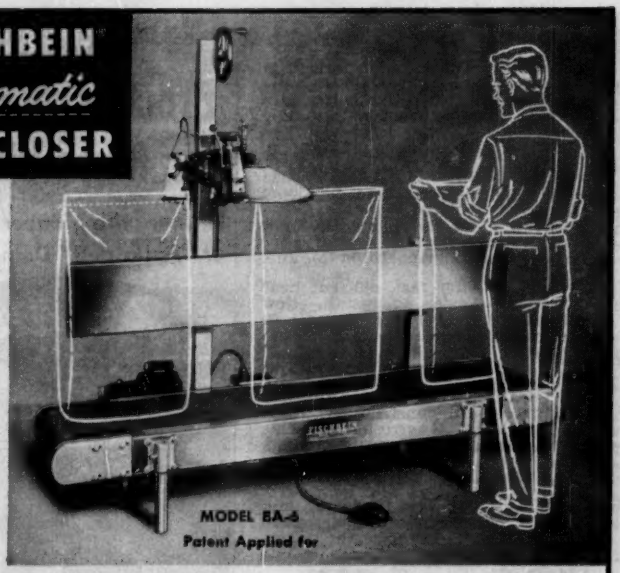
Autoclaves.....A 16-page illustrated catalog on Industrial Heating applications is offered. Engineering service is also available. Send for your catalog.
224 *Posey Iron Works, Inc.

Coils.....Type "R" coils are specially designed for installations where frequent mechanical cleaning of the inside of the tubes is required. Bulletin R-50.
172 *Aerofin Corporation

Fan Sets.....Ready Units are ideally suited for supply or exhaust jobs, indoors or outdoors. Catalog 517 contains 36 pgs. of information, selector charts, dimensions, etc.
50 *Clarage Fan Co.

* From Advertisement, this issue

FISCHBEIN
Automatic
BAG CLOSER



Large Plant Production! Small Plant Price!

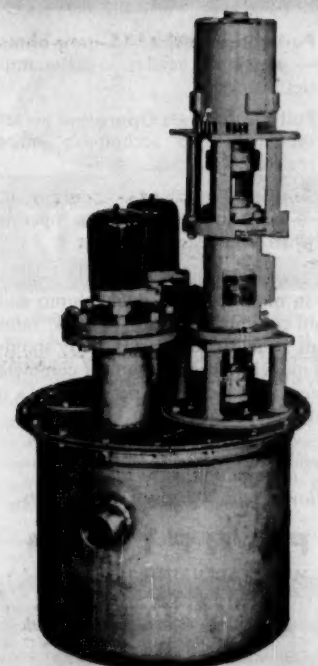
- **Bag activates and completes sewing operation automatically!**
- **Simple mechanical operation . . . Simple installation.**
- **Sews at rate of 30 feet per minute!**

Write for details and complete catalog-file of Fischbein Bag Closing Equipment.

An automatic closing unit. The bags themselves start the sewing operation when they reach the sewing head. After sewing is completed, thread is cut automatically and sewing action stops as conveyor belt continues to move bag.

DAVE FISCHBEIN CO. DEPT. 3C
2720 30th Ave. South, Minneapolis 6, Minn.

Nagle Pumps for the Atomic Age



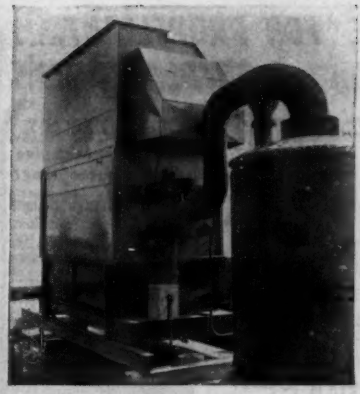
This 1" Nagle type "CWO-CS" vertical shaft, centrifugal pump is ably handling radio active wastes at an atomic plant—one of many Nagle pumps at various atomic energy plants.

All wetted parts of this pump are of stainless steel including the integral tank. No rubbing parts in contact with the liquid. It is designed to pump only 2 g.p.m. Equipped with automatic on-and-off switch and fluid high level alarm system.

A pump in this critical service cannot be babied—a Nagle pump is ideal for this application, because all Nagle pumps are built for abusive applications exclusively.

The leading chemical, mining, and ore processing companies depend on Nagle. Send for Nagle Pump Selector. Nagle Pumps, Inc., engineers and manufacturers, 1235 Center Ave., Chicago Heights, Ill.

Tough jobs call for
Nagle
PUMPS
FOR ABUSIVE APPLICATIONS EXCLUSIVELY



Save Water and Power in Condensing Vapors

NIAGARA *AERO* VAPOR CONDENSERS give sustained full capacity in condensing vapors by evaporative cooling with only nominal use of water. You have no problem of water availability, or disposal, or quality, or temperature.

The system is self-contained...no cooling tower or spray pond is required. You save not only the cost of condensing water but also the expenses of piping and pumping, and the cost of water handling equipment.

In the Niagara Vapor Condenser the heat is removed at the rate of input and the cooling effect, directly proportional to the load, is controlled by varying the amount of air passing over the cooling surfaces. Operation is automatic and trustworthy.

Liquids and vapors are always held at constant temperature under close control. You get uniform distillation products the year round. You get better quality and increased production.

Non-condensibles are effectively separated and sub-cooled, giving you better vacuum pump operation. You save power and steam.

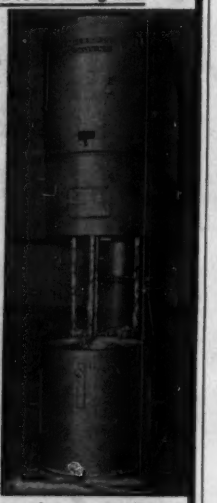
Niagara *Aero* Vapor Condensers are manufactured in standard units in a range of capacities up to thirty million Btu's. Write for full information; ask for Bulletin 129-R.

NIAGARA BLOWER COMPANY
Dept. CE-7, 405 Lexington Ave.
NEW YORK 17, N. Y.
District Engineers in Principal Cities of U. S. and Canada

FOR PROPELLANT___ OR PLASTISOL*

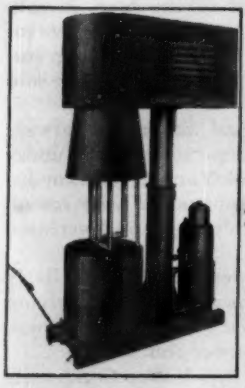
Ross DOUBLE PLANETARY
Change Can Mixers give better mixing in less time!

At *Thiokol*® solid propellant plant in Elkton, Md., this Ross #130CDM variable speed 100 gallon Mixer produces the same high quality mix as obtained in Horizontal Double Arm Kneaders, and in ⅓ the mixing time.



With no bearings or stuffing boxes in the product zone, stationary can, completely enclosed mix, and remotely controlled raising and lowering device, the Mixers are as safe in operation as they are efficient. Mixers have low original and maintenance cost, are easy to clean, and extremely versatile in operation.

Lower illustration shows an 85 gallon #130-CDM Double Planetary Change Can Mixer furnished a leading concern for mixing plastisols of several types ranging up to 200,000 centipoises. Customer reports Mixer in operation 24 hours/day with mixing time per batch only 15-20 minutes; while the quality of mix and dispersion is so high that the final product is obtained in the Mixer alone — without further processing through a Three Roll Mill as was previously necessary with other Mixers.



Jacketed cans for heating or cooling material during mixing, dolly trucks, gates on cans for discharge, and vacuum tight covers can be provided.

*---or any other heavy paste material. On paints, inks, pharmaceutical products, caulking compounds, and other similar materials, the Ross Double Planetary Change Can Mixers mix and disperse up to 30 times faster than other Mixers.

Mixers available in 1, 2, 3, 4, 6, 8, 12, 20, 25, 65, 85, 125 and 150 gallon sizes. Write for complete information on these or other types of Ross mixing, grinding or dispersing equipment!

CHAS. ROSS & SON CO., INC.

Leading mfgrs. of wet or dry grinding Mills, Kneaders and Mixers of all types — since 1869.

150 CLASSON AVE.,
BROOKLYN 5, N. Y.

LITERATURE . . .

Heat Transfer Tubes.....Information on tubes for heat transfer or technical assistance. Specialists are available to help select the alloy best suited to your job.
109 *The American Brass Co.

Heating Mantles.....Glass-fabric type, quartz-fabric type & 650 C Glas-Col "R" type available. Complete line for chem. process, pilot plant and laboratory heating.
59 *Glas-Col Apparatus Co., Inc.

Panelcoil.....offer fast, efficient heat transfer. Easier to install. New Technical Data Sheets Nos. 15-60 series and Price Bulletin 259. Send for your copy.
TR218 *Dean Products, Inc.

Plate Heat Exchanger.....features stainless steel construction which solves almost all corrosion problems or assures sanitary operation. Cleaning is unusually easy. Details.
42-43b *The De Laval Separator Co.

Tube Cleaner.....for condenser and heat exchanger tubes is described in bulletin Y-48. Features pistol-grip which is easy to handle by one operator.
220 *Elliott Co.

Vapor Condenser.....The Aero Vapor Condensers are manufactured in standard units in a range of capacities up to thirty million Btu's. Bulletin 129-R.
R213 *Niagara Blower Co.

Instruments & Controls

Comparators.....give you fast accurate tests for pH, chlorine, phosphate in just 3 simple steps. Handbook has 101-pgs. of tech. data & useful information.
R210 *W. A. Taylor & Co.

Controls, Furnace.....Electr-O-Line, Electr-O-Pulse or Electr-O-Volt will deliver the exact kind of temperature control that's best for your furnace. Details.
26-27 *Minneapolis-Honeywell

Flowmeter.....The True Mass Flowmeter solves your metering problem by giving you a direct, immediate accurate reading in pounds. Illustrated brochure.
187 *Black, Sivalls & Bryson, Inc.

Gas Meter.....The new rotary gas meter is only 14" long, mounts in the line. Accurate to 300 cfh and up to 125 psi. Complete data is available.
157 *Roots-Connersville Blower

Instrument.....Elect-o-probes are now in use for detection of liquors & foam in pulp & paper mills; heavy fluids, acids & fluid interface in chemical plants, etc. Bul.
BL217b *Instruments, Inc.

Instrument.....Radionic for positive on-off control & determination of liquid or solid level within a closed vessel or piping using nuclear radiation. Bul. 558.
BL217a *Instruments, Inc.

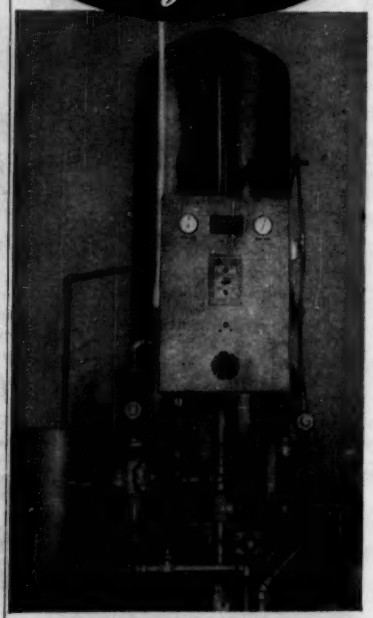
Meter.....The Type 316 stainless steel meter for measuring liquid fertilizer & corrosive chemical solutions. Accuracy ±.5% (20-100 GPM). Descriptive Literature.
TL219 *Badger Meter Mfg. Co.

*From advertisement, this issue

Need Ultra-Pure Process, Make-Up or Rinse Water?

Check the pioneer maker* of "Packaged" Demineralizers

Penfield



- **Purity in excess of 15-meg ohms** — where you need it, in the quantities you need.
- **Fully Automatic Operation** — set one switch to accomplish entire regeneration cycle.
- **Shipped Completely "Packaged"** — each unit is ready to operate when you receive it.

Penfield Demineralizers are available in mono-column, dual-column and multi-column types — in flow rates from 10 to 10,000 G.P.H. Fifty standard models to choose from. If complete system engineering is needed, that's a Penfield specialty too.

Write today for full catalog information. If possible, give flow rate and purity requirements.

PENFIELD
MANUFACTURING CO., INC.
19 High School Ave., Meriden, Conn.

**Penfield pioneered "packaged" demineralizers for American industry — and remains today the only manufacturer exclusively making demineralizing equipment.*

IN ION EXCHANGE COLUMNS AND DEMINERALIZERS

Neva-Clog permits more uniform distribution of regenerating liquors. Its smooth surface allows complete removal of resin in external regeneration systems. Neva-Clog eliminates the need for subfill and avoids its negative side effects such as caustic hideout, silica pick-up, excessive wash water and lengthy wash cycle.

AS SUPPORT FOR GRANULAR CARBON IN PROCESSING COLUMNS

Being stronger and more rigid than woven metallic media, Neva-Clog requires minimum undersupport. Handles all granular carbon. Ideal for flat and conical tower bottoms. Smooth surface facilitates carbon removal. No subfill required; no burlap bags; no gravel mixed with carbon.

IN PRESSURE LEAF FILTERS

Neva-Clog provides excellent precoat characteristics. Leaves do not have to be redressed. Easy to sluice, backwash, scrape.

IN FILTER PRESSES

Neva-Clog gives better drainage than the usual textile and backing screen combination, especially in high pressure filtration.

FOR CENTRIFUGE BASKETS

Neva-Clog's smooth, sheet metal surface permits closest ploughing.

FOR CONTROL OF FUMES AND DUST

Neva-Clog has high gas scrubbing efficiency, without fouling or becoming plugged.

NEVA-CLOG

A double layer, uniformly perforated, offset, double sheet metal medium that functions on the principle of edge filtration, as the magnified illustration shows. It is strong and rigid, yet can be formed into flat or curved panels, discs, plates, cylinders or cones. It has a smooth, non-porous surface; resists abrasion; does not clog, blind or corrode. Its advantages are many; its applications are constantly expanding.

Bulletin 582 tells why. Write.

MM

MULTI-METAL WIRE CLOTH CO., INC.

1353 GARRISON AVENUE, NEW YORK 59, N. Y.

LITERATURE . . .

Meters.....A complete description of Niagara Chemical Meters, including High Pressure, Steam Jacketed, and Electricontact Models is contained in Bul 43.
174 *Buffalo Meter Co., Inc.

Miniature Recorders.....The complete story on the Transcope line pneumatic & electronic recorder housings. Or Bulletins 98286 (pneumatic) & 98335 (electronic).
40-41 *Taylor Instrument Co.

Oxygen Analyzer.....uses a direct paramagnetic measurement exclusively. Detailed specifications on this oxygen analyzer are contained in Data File 14-29-08.
35 *Beckman Instruments Inc.

pH System.....The new pH Dynalog Recorder has an input impedance of 80,000 megohms-eliminates the need for intermediate amplification. Data sheet offered.
49 *The Foxboro Co.

Pneumatic Controller.....Series 624 A/D controllers offered for: pressure & vacuum ranges from full vacuum to 10,000 psi, & temp. ranges from 100F. to +1000F. Data.
32 *The Bristol Co.

Temperature and Pressure Controls.....for your needs. The 1150 Series and the 1110 FultroMatic are shown in detail in Catalog A-NC which is available on request.
182 *Fulton Sylphon Div.

Transistorized Analog Computer..... The TR-10 is a full-fledged analog computer capable of providing solutions to a wide range of design problems. Bul. AC 934-EB.
151 *Electronic Associates, Inc.

Pipe, Fittings, Valves

Expansion Joints.....Catalog 56 contains complete & comprehensive engineering data for expansion joints from 3" to 50' diam., pressures to 3600 psi, temp. to 1600F.
12 *Zallea Brothers

Fittings.....Forged Carbon Steel Fittings offer uniform wall thickness, for safety & accurate machining for tight fit. Specifications & Distributor locations on request.
269 *H. K. Porter Co., Inc.,

Fittings.....Every fitting marked with size, analysis, schedule & production code. Line includes eccentric, reducers, crosses, reducing tees, etc. Catalog data available.
97 *Horace T. Potts Co.

Line Strainers.....for spray nozzle systems & related applications in stainless steel, cast iron & brass. Easily flushed. Bulletin 94 for complete information.
TL209a *Spraying Systems Co.

Pipe, Pyrex.....Complete information about Pyrex Pipe as well as a complete line of Pyrex brand heat exchangers and laboratory drainlines & fittings.
75 *Corning Glass Works

Swivel Joints.....DS series, developed especially for chemical, steam & hot gas service. Name of Field Representative and copy of catalog available on request.
56 *Chiksan Co.

*From advertisement, this issue

Take Guesswork Out of Lab Crushing & Grinding

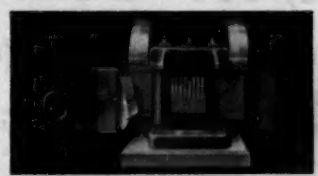
Sturtevant Design Provides Easy Access for Cleanouts — Returns Complete Sample

In seconds, because of "Open-Door" accessibility, all Sturtevant crushing or grinding parts are exposed for thorough cleanouts. 100% sample return is easy to secure.

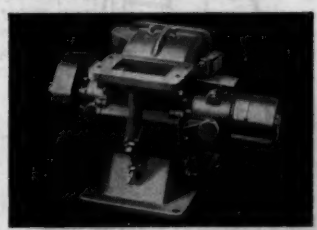
Sturtevant laboratory machines are ruggedly constructed — design, based on production models, gives top lab or pilot performance.

Send for Bulletin No.067, which gives full description of all Sturtevant laboratory machines.

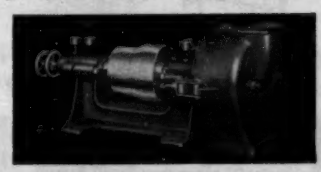
Lab Crushing Rolls: Special lab design. Two models: 8 x 5 in. and 12 x 12 in. rolls. Capacities to 10 tph. Both models adjust down to 20 mesh. Tires of high carbon forgings. Automatic feeder, adjustable controls.



Lab Jaw Crusher: Crushes hardest rocks at ½ to ⅛ in. settings. Roll jaw action — no clogging. Feed opening 2 x 6 in. Capacity to 1900 lbs. per hr. at ½ in. setting. Instant adjustment. Manganese jaws, reversible shield.



Lab Swing-Sledge Mill: 5 x 6 in. opening takes soft, medium, tough or fibrous feed. Capacity to 1 tph. Fines regulate from 1 in. to 20 mesh. Choice of gratings, hammers (or knives).



Sample Grinder: Disc type grinders for dry, friable soft or medium materials. Three sizes — 6 in., 10 in., and 14 in. take feed as coarse as ¼ in. Produces 100 mesh fines at capacities to 200 lbs. per hr. on largest model. Regulate 10 to 100 mesh. In-operation adjustment.

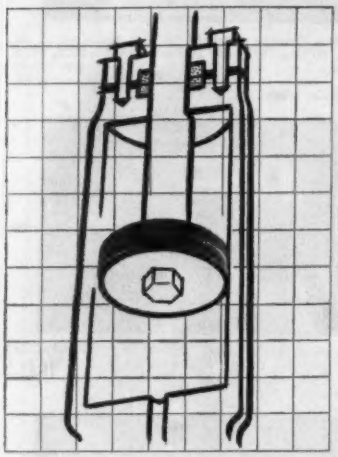
STURTEVANT MILL COMPANY

100 Clayton St., Boston 22, Mass.

R/M CAPABILITY

produces another original in packings

Molded R/M Vee-Flex® rings and R/M piston cups of Teflon*-impregnated asbestos fabric make possible a new design concept



To maintain constant low coefficient of friction without aid of lubrication, R/M developed these new packing rings and piston cups. Check these important advantages never before possible:

- Minimum thermal expansion and plastic flow
- Superior extrusion resistance
- Broad chemical resistance
- Ability to handle all hydraulic fluids
- Operation to 500°F—and under certain conditions to 650°F. Service at temperatures as low as —100°F
- A single type of material to handle both high and low pressures

Get more information on these self-sealing, self-adjusting packing rings and piston cups. Ask for a copy of our folder on R/M Teflon-impregnated asbestos Vee-Flex rings and R/M piston cups, Form P-8907.

*Registered TM for Du Pont fluorocarbon resins

R/M PACKINGS
RAYBESTOS-MANHATTAN, INC.
PACKING DIVISION, PASSAIC, N. J.
MECHANICAL PACKINGS AND GASKET MATERIALS

LITERATURE . . .

Swivel Joints.....for practically all petrochemical & chemical services. Sizes from ⅜" to 12" diameter in steel & from 2" to 12" diameter in aluminum. Catalog.
99 *Continental-Emsco Co.

Tube & Pipe.....Fibercast performs indefinitely with extremely corrosive elements & high temperatures. Complete line of standard fittings as well as couplings available.
171 *Fibercast Co.

Tubing.....A 48-pg. manual for data on Contour-Welded tubing in sizes from ⅛ to 40" O.D., in stainless & high alloy steels, titanium, zirconium, zircalloy & Hastelloy.
77 *Trent Tube Co.

Unions.....Forged steel unions withstand excessive wrench abuse and repeated making and breaking. Features include: cadmium-plated nut, cone-to-ball seat, etc.
16-17 *Clayton Mark & Co.

Valve, Angle.....New all-purpose No. 74 is a universal valve for liquid level gages and/or instrument piping and general use. Catalog sheet offered.
R209 *Jerguson Gage & Valve Co.

Valve, Butterfly.....features true close bearing fit for shaft; non-leaking, non-galling, corrosion-resistant. Bulletin 590X gives all the powerful facts.
R192 *W. S. Rockwell Co.

Valve, Pressure Sealing Gate.....for pressures to 720 psi (cwp) and temperatures to 250 F. Sizes 2" through 30". Additional information in Catalog 1200.
161 *W-K-M Div. of ACF Industries

Valves.....Newest literature on any type of valve including bronze, iron, steel, LPV, plastic and pressure-seal is now available on your request.
48 *Walworth

Valves.....Aloyco Stainless Steel Valves are now available in sizes up to 24", pressures up to 2,500 lbs. at 650 F. New test facilities and research.
159 *Alloy Steel Products Co.

Valves.....Chemical Porcelain valves practically never need maintenance or replacement. Y-Valves & Angle Valves, in ½" to 6" sizes. Also safety valves, pipe, etc. Cat. 567.
155 *Lapp Insulator Co., Inc.

Valves.....You can use Flex Gates with complete confidence on steam, water, gas or oil vapor service. Sizes: 12" & smaller; 150- and 300-lb. pressure classes.
141 *Crane Co.

Valves.....New Gate & Globe valves are available in ¼" thru 2" sizes & in both socket weld & screw ends. Feature extra deep stuffing box for long packing life. Literature.
110 *Henry Vogt Machine Co.

Valves, Coated.....Complete details, specifications and application data on the new coated valves. Now available with K-51 & Kanigen coatings.
173 *Rockwell Mfg. Co.

Valves, Gate.....Information Folder No. 205 describes the Ni-Resist Gate Valves. "Ni-Resist" extends the valve life in corrosive and erosive services.
139 *Jenkins Bros.

* From Advertisement, this issue

DRAVO DISCS
offer these plus values for pelletizing and mixing . . .

- Pellet uniformity is far superior to that produced by other methods.
- Continuous operation (not batch) assures higher production rates.
- Binder is unnecessary in many cases.
- Low overall cost per ton of output.
- Material in process can be viewed continuously.

Send for Bulletin Number 247.
Write Dravo Corporation,
Pittsburgh 25, Pennsylvania.

DRAVO
CORPORATION

Manufactured under license agreement with Lurgi of Frankfort, Germany.

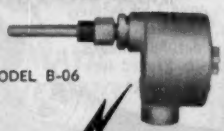
IF YOU NEED . . .
LEVEL INDICATION • DETECTION • CONTROL

BY RADIATION . . .

For positive on-off control and determination of liquid or solid level within a closed vessel or piping using nuclear radiation. Mounted externally. RADIONIC is used NOW for CO_2 fill control, uranium ore hoppers, food container filling, varnish blending, acid slurry refining, asphalt pots, 'green salt' reactors, high energy jet fuels, latex drums, electrical transformer case filling.

Write for Bulletin No. 558

BY CAPACITANCE . . .



A capacitance operated super-sensitive electronic relay. Detects liquid or solid levels, liquid-liquid or foam-liquid interface*. Probe mounted internally. ELECTR-O-PROBES® are NOW in use for detection of liquors and foam in pulp and paper mills; heavy fluids, acids and fluid interface in chemical plants; alarm for refrigerant control in freezing plants; mixed feeds; water-oil interface; fluids in dairies, breweries, etc.

Write for Bulletin No. B-06

* *Model B-06 shown features unitized explosion-proof construction, plug-in components, tank side mounting.*

INSTRUMENTS INCORPORATED
TULSA

INSTRUMENTS, INC.
BOX 556 • TULSA, OKLA.
PIONEERS IN LEVEL MEASUREMENT AND CONTROL INSTRUMENTATION

DARNELL
CASTERS & WHEELS
have all these advantages

1 RUBBER TREADS

. . . a wide choice of treads suited to all types of floors, including Darnelloprene oil, water and chemical-resistant treads, make Darnell Casters and Wheels highly adapted to rough usage.

2 RUST-PROOFED

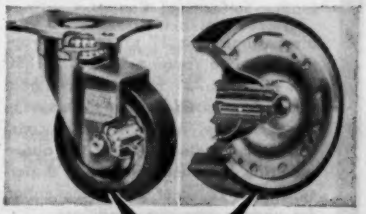
by zinc plating, Darnell Casters give longer, care-free life wherever water, steam and corroding chemicals are freely used.

3 STRING GUARDS

. . . Even though string and ravelings may wind around the hub, these string guards insure easy rolling at all times.

4 LUBRICATION

. . . all swivel and whee bearings are factory packed with a high quality grease that "stands up" under attack by heat and water. Zerk fittings are provided for quick grease-gun lubrication.



FREE MANUAL — For the full story

Look in the Yellow Pages for your Darnell Distributor under "Casters".

DARNELL CORPORATION, LTD.

DOWNEY (Los Angeles County) CALIF.
37-28 SIXTY-FIRST, WOODSIDE 77, L.I., N.Y.
36 NORTH CLINTON ST., CHICAGO 6, ILL.
1000 PEACHTREE N. E., ATLANTA, GA.

gives RUGGEDNESS and VERSATILITY to new FIKE CPV UNIT

A holddown ring is the added feature that gives the new Fike CPV rupture disc unit a distinct advantage over conventional units. The close fitting holddown ring holds the rupture disc snugly to the vacuum support. This reduces wrinkling and possible fatigue failure in cycling vacuum and pressure service. It also protects fragile discs from being cut by excessive tightening.

The Fike CPV unit is more rugged than conventional rupture discs of equal rupture pressure. It is more easily handled and there is less danger of damaging the rupture disc during installation from over torque or slight inclusion of foreign matter on seating surfaces of flanges.

Sizes range from 1" to 24" with rupture pressure ranging from 4 to 850 lbs. PSIG at 72° F. Metals available depending on size, include aluminum, copper, silver, nickel, monel, inconel and stainless steel. Any of the above materials furnished with plastic dispersion coats or sheet plastic lamination for various corrosive conditions.

Send for the new complete catalog on Fike Rupture Discs.

Fike

METAL PRODUCTS CORP.
Blue Springs, Missouri

LITERATURE . . .

Valves, Line Blind.....for positive action, easy operation, long-life service and lasting safety. Feature absolute line shut-off by one man in one minute.
180 Well Equipment Mfg. Corp.

Valves, Pinch.....with 1" to 14" inside diameter, pressures to 150 psi & temperatures to 200 F. Can be equipped for automatic regulation. New Catalog.
L211 *Mine & Smelter Supply Co.

Process Equipment

Agitators & Mixers.....Turbine-type propeller (to 120" in tanks to 50" dia.) slow speed, high speed, air lift, vertical turbine mixers, mixer-settler units. Bul. A2-B2.
191a *Denver Equip. Co.

Attrition Scrubbers.....High power input to efficiently remove sand coating, mix dense slurries. Rubber lined or acid-proof tanks. Sizes to 56" 56". Bul. A-8505.
191b *Denver Equipment Co.

Ball & Rod Mills.....offer operation & convertibility. Wet or dry grinding systems. Sizes to 10' x 20'. All steel construction. Bulletin B2-B20.
191c *Denver Equip. Co.

Centrifugal.....The link suspended, stationary curb centrifugal machine features direct coupled hydraulic motor and oversize anti-friction bearings.
208 *The Western States Machine Co.

Centrifugals.....Batch-O-Matic design can handle greater out-of-balance loads with minimum vibration. Low speed plowing prevents crystal degradation. Bulletins.
196 *American Machine & Metals

Converters.....Chemical & Plastic converters are available in a variety of sizes. Complete information on all models is available on your request.
TL221 *Mitts & Merrill

Demineralizers.....are available in mono-column, dual-column & multi-column types . . . in flow rates from 10 to 10,000 GPH. Fifty models to choose from. Catalog.
R214 *Penfield Mfg. Co., Inc.

Discs.....Material in process can be viewed continuously. Binder is unnecessary in many cases. Bulletin No. 247 covers all the features and applications.
TL217 *Dravo Corporation

Dryers, Pan.....are researched and engineered to do the most efficient job possible. Details on Pan Dryers are contained in Bulletin 351.
L193 *Bethlehem Foundry & Machine Co.

Evaporators.....for all chemicals . . . acids, salts, pharmaceuticals, recovery of industrial waste. Details on the complete Buflovak evaporator line in Catalog 372.
204 *Blaw-Knox

Filter, Automatic.....Model HRC has horizontal plate cake stability plus artomatic cake discharge. Operations including precoating & cleaning can be fully automated.
46 *Sparkler Mfg. Co.

* From Advertisement, this issue

SPECIAL SHAPES AND SIZES NO DIFFICULTY
With Superior
DEAN PANELCOIL

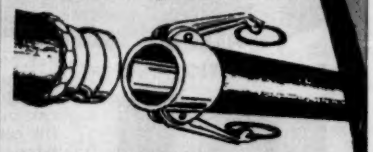
Heating Conical Bottomed Tank — Heating Special Blender

Dean Panelcoil offers dollars and cents advantages over old-style pipe coil and conventional integral jacketing, regardless of shape or size. Low in cost. Faster, more efficient heat transfer. Easier to install. Lighter. Better in every way.

For complete engineering and pricing data, write for new Technical Data Sheets Nos. 15-60 series and Price Bulletin 259.

DEAN PRODUCTS, INC.
1039 Dean Street, Bklyn. 38, N. Y.
STerling 9-5400
Backed by 25 Years of Panel Coil Manufacturing

SAVE TIME
WITH KAMLOK QUICK COUPLERS



CUT YOUR MAINTENANCE COSTS

Save production time by replacing hose and pipe connections with Kamlok Quick Couplers. Used wherever hose and pipe connections are periodically uncoupled. Fast . . . Safe . . . Sure. No tools needed. Just fit together and pull the cam arms down. Lock securely in place. Leakproof gasket cannot fall out. All Kamloks 100% master gauged for complete interchangeability.

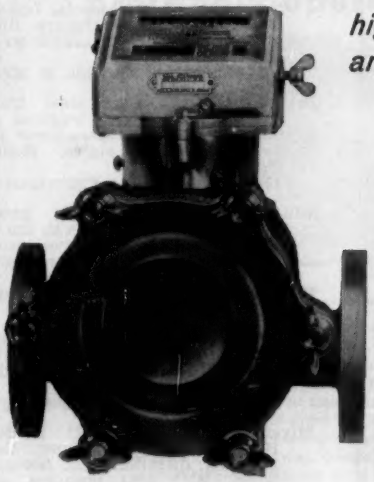
KAMLOKS are available from stock in bronze, aluminum, stainless steel, monel and semi-steel from ½" through 6" sizes. 39 different styles to choose from. Specials to fit your needs. Get full details.

Send for Handbook F-10R

KAM 2

OPW-JORDAN 6013 WIEHE ROAD CINCINNATI 13, OHIO

Badger's 2" stainless steel meter with magnetic drive...



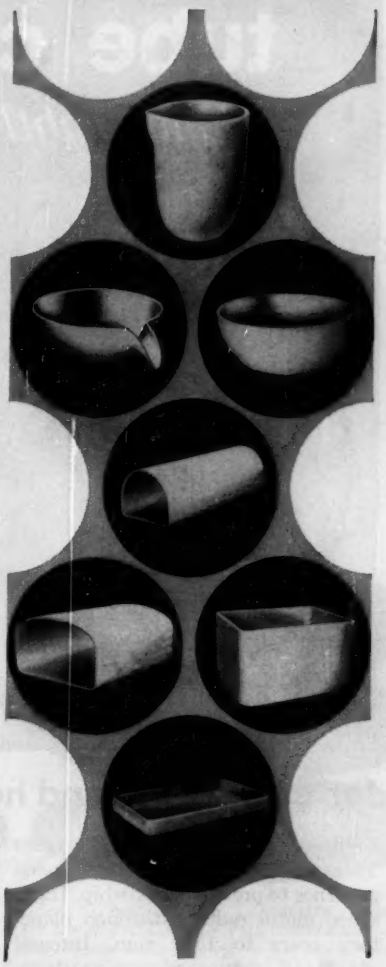
high accuracy on chemical and fertilizer applications

- Ruggedly constructed of Type 316 stainless steel for measuring liquid fertilizer and corrosive chemical solutions.
- Key maintenance features: simple design, take apart construction for easy, quick cleaning. Magnetic drive eliminates packing gland.
- Accuracy ±.5% (20-100 GPM), operating pressure to 150 PSI, and temperatures to 150° F.
- Order with low-cost standard totalizer, combined gallon totalizer and reset totalizer or electric batch. Can be equipped with remote reading Read-o-Matic register as accessory.
- *Typical uses:* measuring, blending, batching of liquid corrosive chemicals and fertilizers in manufacturing and bulk plant operations.

Write for descriptive literature

Badger Meter Mfg. Co.
Industrial Products Division
4545 W. Brown Deer Rd. • Milwaukee 23, Wis.

VITREOSIL®
PURE FUSED QUARTZ



FINEST QUALITY IN INDUSTRIAL WARE

- Absolute Chemical Purity
- Extreme Heat Resistance
- Thermal Shock Resistance
- Chemical Inertness
- Outstanding Electrical Properties
- Full Range Radiant Energy Transmission

VITREOSIL easily meets critical production requirements . . . replaces more costly materials. Available in many types and sizes. Also fabricated to your special needs. See our ad in **Chemical Engineering Catalog.**

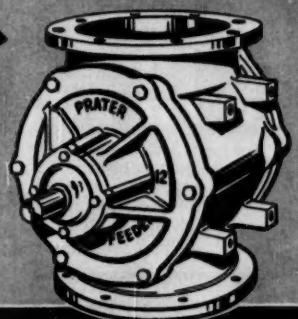
Write for complete, illustrated catalog.

THERMAL AMERICAN FUSED QUARTZ CO., INC.
18-20 Salem St., Dover, N. J.

PRATER ROTARY AIRLOCK FEEDERS
for
DUST CONTROL and PNEUMATIC CONVEYING

Write for "How to Select A Rotary Airlock Feeder" Bulletin P58

the recognized LEADER

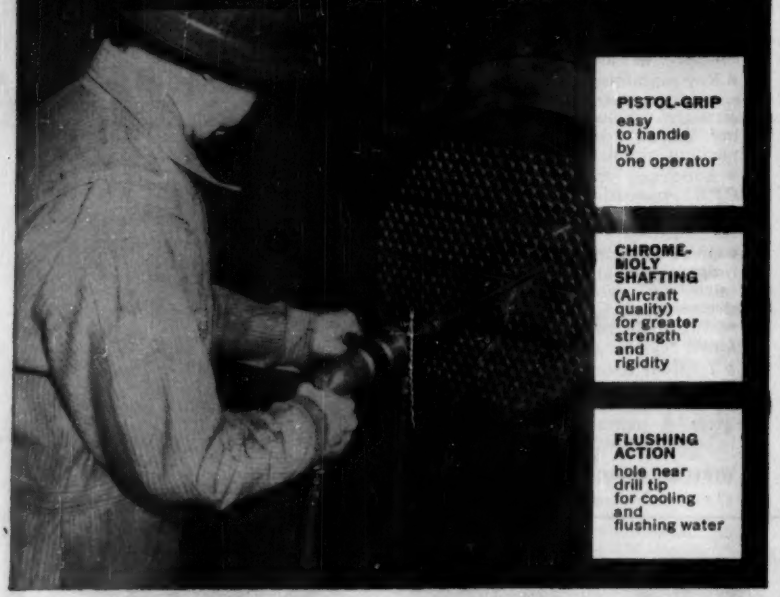


FOREMOST BUILDERS OF ROTARY AIRLOCKS

PRATER PULVERIZER COMPANY
1517 South 55th Court — Chicago 50, Illinois

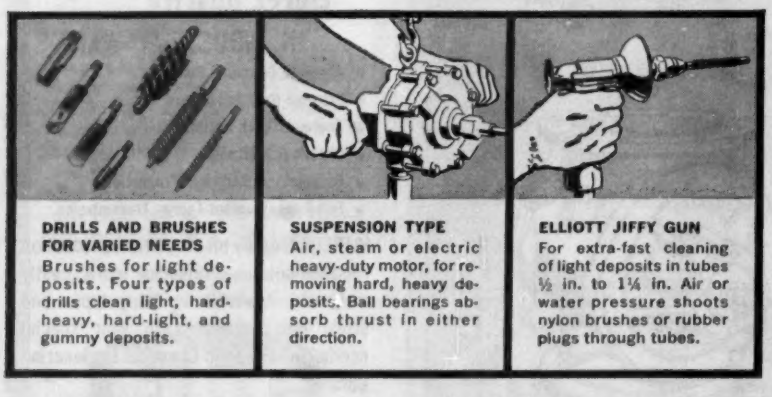
newest ELLIOTT tube cleaner

lightweight! air-driven!


PISTOL-GRIP
easy to handle by one operator
CHROME-MOLY SHAFTING
(Aircraft quality) for greater strength and rigidity
FLUSHING ACTION
hole near drill tip for cooling and flushing water

for condenser and heat exchanger tubes

Lightweight. Powerful. Air-driven. Trigger-action control with speed governor to prevent shaft-whip. High-speed motor reduced through planetary gears to 1500 rpm. Integral water-feeding attachment with finger-action valve which controls flow of cooling water into hollow shaft and drill or brush. Built-in oil reservoir. Send for tube cleaner bulletin Y-48.



DRILLS AND BRUSHES FOR VARIED NEEDS
Brushes for light deposits. Four types of drills clean light, hard-heavy, hard-light, and gummy deposits.

SUSPENSION TYPE
Air, steam or electric heavy-duty motor, for removing hard, heavy deposits. Ball bearings absorb thrust in either direction.

ELLIOTT JIFFY GUN
For extra-fast cleaning of light deposits in tubes ½ in. to 1¼ in. Air or water pressure shoots nylon brushes or rubber plugs through tubes.

ELLIOTT Company
Lagonda Plant—Springfield, Ohio

Y3-1

LITERATURE . . .

Filters.....Operating with process streams from 5 to over 1,000 gal. per minute, Niagara Filters can be adapted to automatically process hundreds of materials. Data.
197 *American Machine & Metals

Filters.....Details on size, construction materials and special features of FEinc rotary pressure filters plus other data is available on request.
195 *American Machine & Metals

Jaw Crusher.....Cast steel frame, anti-friction side bearings & bumper bearings. Manganese steel jaw and check plates. Bulletin C12-B12.
191d *Denver Equipment Co.

Mill.....Jet-O-Mizer Mills process many types of materials in the following industries; abrasive, insecticide, ceramic, food, mineral, pharmaceutical, etc. Information.
179 *Fluid Energy Processing & Equip.

Mills.....Pebble & Ball Mills are available in a complete range of sizes from 40 to 13,000 lb. capacities for grinding, mixing, and blending. Catalog 77.
R211 *Abbe Engineering Co.

Mixer.....New Model RL Hi-Shear Head Mixer offers finer, faster blending, dispersing and homogenizing. All parts stainless steel. Chemically inert seals.
231 *Gabb Special Products Inc.

Mixer, Stainless Steel.....Complete information on the stainless steel jacketed vertical mixer. Polycarbonate resin can be blended in this mixer. Bul. 192.
205a *Sprout, Waldron & Co.

Mixers.....The widest possible choice of standard mixer designs in sizes up to 500 hp. Additional information on all types that are now available.
236 *Mixing Equipment Co., Inc.

Mixers.....for agitating, mixing, reacting, suspending solids, blending miscible liquids, circulating, heat transfer and continuous treating. Bulletin 581.
143 *Nettco Corp.

Mixers.....Model "LF" Mix-Muller has a capacity of ¼ to ¾ cu. ft. Has machined crib and mullers. The Handbook on Mulling is available on request.
107 *National Engineering Co.

Mixing.....Ko-Kneaders mix a wide variety of products such as plastics, carbon electrodes, food specialties, floor tile, solid rock propellant fuel & many others. Manual K-57.
89 *Baker Perkins Inc.

Mixing & Grinding Equipment..... Complete information on dry crushing and pulverizing mills, hopper mills, high speed dissolvers or dispersers, & mixers of all types.
L214 *Charles Ross & Son Co.

Pilot Plant.....is equipped with the mixing, heating and reaction equipment necessary to do a comprehensive pilot plant evaluation. Information available.
42-43a *The De Laval Separator Co.

Process Equipment.....“Sub-A” Flotation is available in sizes from 16” x 16” to 72” x 72”. “Cell-to-Cell”, “Free-Flow”, and Type “M”. Bulletin F10-B86.
191f *Denver Equipment Co.

* From Advertisement, this issue

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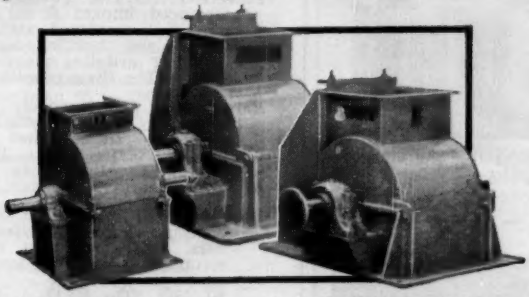

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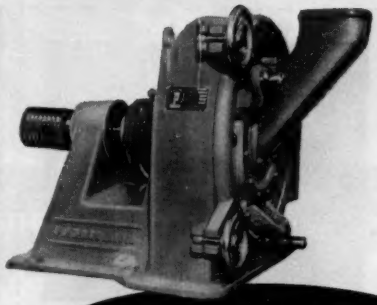

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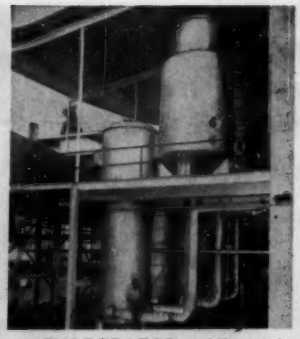

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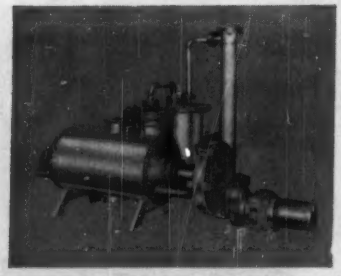

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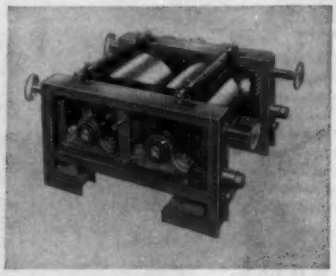

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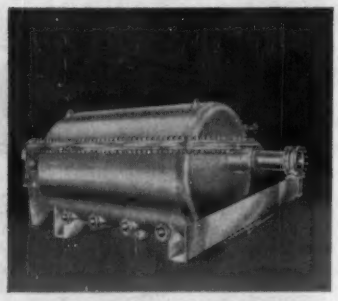

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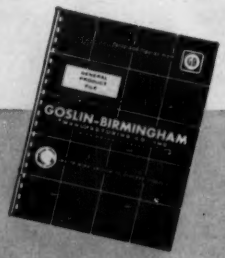

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Process Equipment.....custom designed to meet your specific requirements. Detailed information on evaporators, vacuum rotary dryers, drum dryers, filters, etc.
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98 *The Strong-Scott Mfg. Co.

Pulverizers.....the modern units for wet or dry operation, small or large capacities. Employ three principles of reduction: Turbo, Impact & Shear. Literature.
221 *Pallmann Pulverizers Co., Inc.

Purifiers.....Specification Manual 803 contains data on 13 types of purifiers, separators, mist extractors, scrubbers. Available now on request.
BL221 *The V. D. Anderson Co.

Reagent Feeders.....Both wet and dry feeders are available. Many standard units in stock. Complete information contained in Bulletin F6-B8.
191e *Denver Equip. Co.

Rotary Airlock Feeders.....for dust control and pneumatic conveying. Bulletin P58, "How to Select A Rotary Airlock Feeder" is now available.
BL219 *Prater Pulverizer Co.

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Screen Separator.....The Syncro-Matic offers single, double or triple decks of plain or composite screens in a full range of commercial meshes & materials. Data.
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106 *Western Precipitation

Separators.....in service for any problem involving liquid-vapor separators or wet and dry type dust scrubbers & gas filters. Details available.
R193 *Peerless Mfg. Co.

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Spray Nozzles.....Catalog 24 contains 48-pages of reference data on thousands of spray nozzle designs and sizes. Choice of capacities, characteristics & materials.
TL209b *Spraying Systems Co.

Turba-Film Processor.....consists of a series of rotor blades operating within a thermal section & a separating section . . . all fabricated of alloy steel. Bul 117.
60 *Rodney Hunt Machine Co.

* From Advertisement, this issue

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Air Compressor.....Aimed primarily at air separation plants but also for other industrial uses, a new centrifugal air compressor is completely described.
223A Clark Bros. Co.

Compressors.....Dynamic Compressors are available in both centrifugal & axial designs, with a capacity range from 15 to 15000 HP. Complete details in Bul. 1491-11.
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Pump.....Class "RR" pump for clear water service . . . hot or cold . . . against heads as high as 1500 feet . . . at capacities up to 900 gpm. Information in Bul. 980-D.
4 *Buffalo Forge Co.

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223 *Wallace & Tiernan Inc.

Pump, Centrifugal.....The CENTRICHEM handles most chemicals, including slurries with particle size up to 1/16 of an inch, as well as troublesome sticky fluids. Lit.
54c *Eco Engineering Co.

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191g *Denver Equipment Co.

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54b *Eco Engineering Co.

* From Advertisement, this issue

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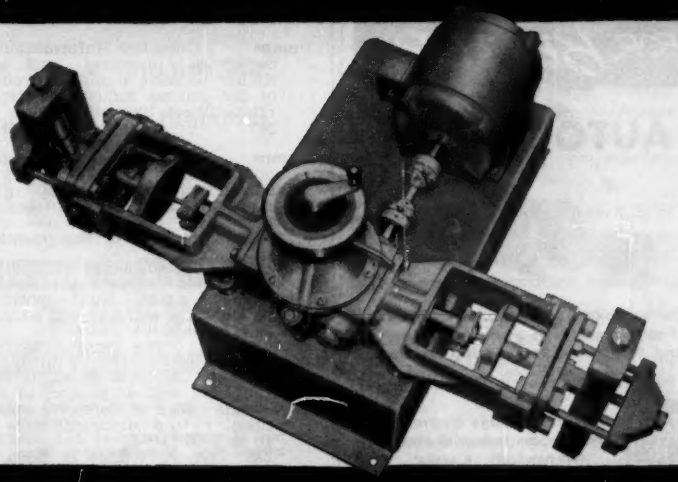

Before We Designed This New Pump

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LITERATURE . . .

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207 *Aldrich Pump Co.

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191i *Denver Equipment Co.

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163 *The Duriron Co., Inc.

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34d *Eco Engineering Co.

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93 *Lukens Steel Co.

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230 *Hardinge Co., Inc.

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ADDITIONAL EQUIPMENT ADVERTISING on pages 226-229

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Stokes, DD2, DDS2, T, "R", and "F" Tablet Presses.
Nash Vacuum Pumps: H6, T57, #2.

PARTIAL LIST **SEND FOR CIRCULAR**

Ask About Our Rebuilding Services

BRILL EQUIPMENT CO.
35-65 JABEZ STREET
NEWARK 5, N. J.

Tel.: Market 3-7420 ● Cable: Bristen
TEXAS OFFICE—4101 San Jacinto St., Houston 4, Texas—Tel.: Jackson 6-1351

CIRCLE A ON READER SERVICE CARD

SPECIAL

SPROUT-WALDRON 10,000# HORIZ. SPIRAL MIXER

Centrifugals: 12", 30", 40" & 48".
Centrifuges: Sharples #5 & #8 Stainless.
Dryers: Hersey 5'x26' Rotary, 316 Stainless
Buffalo Vac. Drum Dryer 24"x20".
Lydon elec. heat Dryer 8 trays.
Despatch Ovens Elec. Heated.
Devine Vac. 8 shelf Dryer 38" x 42".
Hope Stainless Can Filler pts. to gals.
Filters: Valles 49 S. S. covered leaves.
#2 Sweetland 12 Stainless Leaves.
Filter Presses: 6" to 36" Iron & Wood.
Kettles: S.S. Jac. 20 to 500 gals.
Dopp 350 gal. cast iron Jack. Vacuum.
Devine Impreg. Units 30" & 36" dia.
Mills: Raymond #00, 30 HP. & #0000.
Mikro Pulverizers #4, 2, 1, & Bantam.
Hammer Mills & Pulverizers 3 to 50 HP.
Rotary Cutters 1½ to 5 HP. & up.
Spr. Waldron Stainless spike crusher.
Pebble, Jar & Ball Mills, Lab. to 6' x 8'.
3 Roll, 9" x 32", 12" x 30", 16" x 40".
Lehman 4 Roll W.C. 12' x 36" Steel.
Colloid Mills 1½ H.P. & up.
Mixers: Baker Perkins jack, 100 gals.
Day Imperial 75 & 150 gals.
Change Can Mixers 8, 15, 40 gals.
Day Jumbo 700 gal. horiz. mixer.
Blystone 3000# horiz. spiral mixer.
Day 1000# Ribbon Mixer & other sizes.
Lancaster 6' dia. 25 HP. & #1. HP.
Pumps: Stokes etc. Vac. 10 to 500 CFM.
Gould 75 HP. Centrifugal 250 PSI.
Sifters: Day, Robinson, Rotex type.
Tablet Machines: Stokes Rotary RD3
Colton 4½T & 2B Single Punch
Hydr. Presser, Plastic & Rubber Machy.
Partial Listings. Write for Bulletins

STEIN EQUIPT. CO.
107-8th St., Brooklyn 15, N. Y. ***Sterling 8-1944***

CIRCLE B ON READER SERVICE CARD

LOEB OFFERINGS

Autoclave: 50 gal. Struthers Wells, st. st.
Centrifugal: Tolhurst 20" st. steel (New).
Centrifugal: AT&M 60" st. st. perf.
Concentrating Table: Deister #14, 5' x 8'.
Dewaterers: Davenport 3A, bronze hd. 3 hp.
Disintegrator: Riets RD18P, 75 hp.
Dryers: Devine 2 x 4' vac. drum, st. steel.
Dryer: Bowen lab. spray st. steel.
Dryer: American atmospheric 24 x 48".
Evaporator: Buflovak st. st., 94 sq. ft.
Filter: Oliver precoat 12x2" st. steel.
Heat Exchangers: 400 sq. ft. st. st. tubes.
Homogenizers-Dispenser: Tri-Homo #10, #4
Kettles: st. steel, with and without ag.
Dopp 150 gal. dbl. act. agitator.
Mills: Mikro Atomizer 5MA st. steel.
Day 3-roll high speed 14x30".
Colloid, 3, 5, 20, 25 hp.
Mixers: Dbl. and sgl. arms sigma blade.
Dry Powder, various sizes.
Mix-Muller: Simpson Porto 39" st. steel.
Pumps: Rotary, gear, centrif., vacuum.
Screen: Rotex model 41 st. steel.
Still: Double effect st. st. 11.83 gal.
Tablet Press: Stokes DD2, 23 station.
Truck Tanks: Stain. steel 1200, 1600 gal.
Vacuum Pans: 42" and 72" stain. steel.

LOEB EQUIPMENT SUPPLY CO.
820 WEST SUPERIOR ST. · TELEPHONE Sterling 8-1421 · CHICAGO 22 ILLINOIS

CIRCLE C ON READER SERVICE CARD

DIESEL LOCOMOTIVES & CRANES

7—115 ton 100 ton 45 ton 60 ton Gen. Elec.
3—New 25 Ton, 2 GE I Whitcomb.
1—44 Ton, 1-80 Ton Used Gen. Elec.
1—25 Ton, Industrial 60' Boom Loco. Crane.

PLANT EQUIPMENT

4' Telsmith TY Gyratory Crusher.
2—Wemco 2M-HMS-Plants.
No. 5060 Dixie Mogul Hammermill 500 H. P.
2—6' x 36' Hardinge Ball Mills.
2—5' x 8' Kennedy Van-Baun air swept Ball Tube Mills with Motors & Elec. Eye.
7' x 24' Allis-Chalmers Tube Mill.
5' x 10' & 7' x 15' Rod Mills.
14" x 28" & 30" x 36" Traylor Type H Jaw Crushers.
48" x 72" Buchanan Type "C" Jaw Crusher.
56" x 72" Traylor Style G Jaw Crusher.
No. 1 Sturtevant Rotary Fine Reduction Crusher.
2' Symons Standard Cone Crusher.
322 AC Type R Hydrocone Crusher.
207-10 Type 316 SS LB Roto Louver Dryer.
30" x 20' Ruggles Coles Class XF-1 Rotary Dryer.
36" x 30' Hardinge Brick Lined Rotary Kiln.
#207-10 & #705—24 Link Belt Roto Louver Dryers.
Link-Belt Meno-Tube 24-10 Dryers.
54" x 35' Louisville Monel Steam Tube Dryer.
72" x 28' Madison Rotary Dryer.
5' x 30' Ruggles Coles Class XA-8 Rotary Dryer.
8' x 60' Rotary Dryer, ½" Welded Shell in Calif.
3' x 30' & 9' x 160' Vulcan Rotary Kilns.
42" x 18" Traylor Type AA Crushing Rolls.
5'-6" x 60' Rotary Dryer or Cooler.
F35 Syntron Grizley Feeder.
24" x 95' NEW Hewitt Robins Truss Belt Conveyor.

R. C. STANHOPE, INC.
60 E. 42nd St. N. Y. 17, N. Y.
Tel. MU 2-3075

CIRCLE D ON READER SERVICE CARD

CHEMICAL EQUIPMENT DIVISION

Raymond 3 Roll #3036 Hi-Side Mill
Buflovak 18 Shell Vacuum Shelf Dryer
1000 sq. ft. Stainless Heat Exchangers (2)
Tolhurst 40" S.S. Center Slung Centrif.
Fletcher 40" Susp. Steel Centrifugal
Sweetland #12, #10, #7 Filter Presses
30 Gal. S.S. Jktd. Autoclave 1000 PSI Int.
Shriver 30"x30" P&F 36 C.I. Chambers
Nooter 750 gal. Steel Reactor 300 PSI
Traylor 8' x 11' Ball Mill
Allis-Chal. 8'x60'x¾" Welded Rotary Kilns
Vulcan 6'x124'x½" Rotary Kiln
Link Belt 502-16 Roto-Louvre Dryer
8' x 80' Rotary Dryer 316 S.S.
Mosser 4' x 47' Rotary Dryers
Louisville 6'x50'; 6'x25' Steam Tube Dryer
Stainless Tanks 100, 200, 350 gal.
Condensers 100 to 5000 sq. ft. Steel; Admir.
Pressure Vessels 300 to 4500 gal.
Dixie #5060 Mogul Hammermill
Raymond #50, #40 Impact Mills

HEAT & POWER CO. INC.
60 E. 42nd St., New York 17, N. Y.
310 Thompson Bldg., Tulsa 3, Okla.

CIRCLE E ON READER SERVICE CARD

JULY SPECIALS

2 Oliver Rotary Vac. Filters, 3' x 2', 63" x 8'
3 Bird Filters, 18" x 28", 4' x 1' & 24"
Gruendler "BB" Hammermill, Whirlbeater
Pfaudler 1500 gal. glass closed top Tank
Gen. American 42" x 120" Twin Drum Dryer
Colton #5½ Preformer, max. size 3" x 2½" tablet
Rotex Sifter 20" x 48", on high stand, ½ HP mtr.
Abbe 5' x 6' J'ktd. Ball Mill, chrome mang. steel
Ribbon Blenders, Steel & SS, all sizes, New & Used

WHAT HAVE YOU FOR SALE OR TRADE?
YOU CAN BANK ON

EQUIPMENT CLEARING HOUSE, Inc.
111 33 Street Brooklyn 32, N. Y.
SOuth 8-4451—4452—8782

CIRCLE F ON READER SERVICE CARD

BUY ON TERMS!

NEW WESTBILT MIXERS

In Stock

2—New 40 cu ft Westbilt Double Ribbon Mixers. 30" wide, 8' long, center discharge. Covers, with or without Motor.

Immediate Delivery

ME MACHINERY AND EQUIPMENT CO.
123 Townsend St. · San Francisco 7, Calif.

CIRCLE G ON READER SERVICE CARD

FOR SALE

LABORATORY, PILOT PLANT & PRODUCTION EQUIPMENT

Instron, Floor Model TT-C;—Atlas Weathermeter Model DMC-HR;—60 lb. Rigid Urethane Foam Machine & 20 lb. Newton Urethane Foam metering & mixing Machine, both with Traverse, Auto. Timers & Controls;—Lanly Dry & Humid Oven with Dry & Wet Bulb Recording;—Minn.-Honeywell Recording Potentiometer;—Explosion Proof Admiral Refrigerator;—Dillon Floor Model L Dynamometer;—Zeiss Mono. Microscope;—Danley ASTM Compression Set Dies;—Scientific Model 161 Constant Temp. Bath;—DeVilbiss Resin Spray Unit with Tanks & 3 Dual Guns;—3 Monorail Systems, Hoists, Motors, & additional misc. equipment. Equipment approx. three years old. Condition Excellent.

ENGLANDER PLASTICS DIV.
330 N. Warwick Ave. Baltimore 23, Md.

CIRCLE H ON READER SERVICE CARD

LIQUIDATING

T316 SS CHEMICAL EQUIPMENT
ORANGE, TEXAS

1—Struthers-Wells 3500 gal. T316 SS reactor, jkt. & 40/20 HP Agit., w/int. T316 SS coil
1—Alco 110 sq. ft. T316 SS vert. pressure leaf filter.
2—Vulcan 96" dia. T316 SS bubble cap columns, 37' high
1—Vulcan 72" dia. Copper column, 4' high, VACUUM.
1—17,650 gal. T316 SS horiz. tank, dished heads, coil
3—Worthington 160 ton steam-jet Vac. refrigeration units.
2—Sharples #C-20 Super-D-Hydrators, T316 SS
2—Buffalo type #R, T316 SS blowers, 2330 cfm, 60 HP
2—American type #R, T31 SS blowers, 5600 cfm, 50 HP
2—Read 1800 cu. ft. T304 SS weigh hoppers, with T304 SS elevators, shaker conveyors, etc.
1—Struthers Wells 630 sq. ft. T316 SS evaporator.

MANY, MANY OTHER ITEMS
SEND FOR ILLUSTRATED CIRCULAR #1259A

TANKS—VESSELS

2—18,000 gal., vert., alum., 12' x 31', cone bottom
1—17,650 gal., horiz., T316 SS, 9' x 36', ¼" shell, ⅜" dished heads, 40# WP.
1—5800 gal., vert., alum., 10' x 10', agit.
10—4500 gal., vert., Nickel-clad, 8' x 11', 125# WP.
1—3700 gal., vert., T304 SS, 6' x 17' VACUUM, int. coils.
1—3300 gal., vert., T304 SS, 6' x 14'6", ⅜" shell, ⅜" heads, 70# WP.
1—2750 gal., vert., T316 SS, 7' x 8', dished heads, 50# WP, 75 sq. ft. coil.
4—2600 gal., vert., T316 SS, 7' x 8', flat bottom, 15# WP, 5 HP agit.
1—2500 gal., vert., T316 SS, 7' x 7', ¼" shell, 5/16" dished heads, 70# WP.
5—2250 gal., vert., T316 SS, 7' x 6'3", dished heads, 70# WP, 5 HP agit.
1—2100 gal., vert., T316 SS, 6' x 9'10" open top, cone bottom.
1—2100 gal., vert., 6' x 10', dished heads, rubber lined.
1—2100 gal., vert., alum., 6' x 10', dished heads.
1—1900 gal., vert., T316 SS, 6' x 8', ⅜" shell & dished heads, VAC. or 100#.
12—1750 gal., vert., hoppers, T304 SS, double cone bottom.
100—Tanks & vessels, 100 to 1000 gal., all types, etc.

JUST PURCHASED

1—Baker-Perkins #15-UUMM 100 gal. Dispersion mixer, 100 HP, jacket, compression cover, screw tilt, cored blades
2—Buflovak VACUUM Shelf Dryers; 110, 98 sq. ft.
3—National Iron 10' dia. x 78' long rotary dryers, ¾" shell, 4' dia. center tubes. Excellent condition

FILTERS—CENTRIFUGALS

1—Niagara #510-28, 510 sq. ft. vert. leaf, T316 SS, ASME.
1—Alco 110 sq. ft., T316 vert. filter.
1—Niagara #53-36 T304 SS filter.
1—Elmco 18" dia. x 24" face T304 SS rotary vacuum.
2—Oliver 5'3" dia. x 3' face rot. vac., pressure precoat, T316 SS, ASME 30# pressure housing.
1—Oliver 5'3" dia. x 8' face, rot. vac., precoat, steel; UNUSED.
39—Sharples #AS-16V super cent. Inconel, Vapor-tite, 3 HP, sludge disch.
2—Sharples #16P, T304 SS pressure-tite.
5—Sharples #C-20, C-27 Super-D-Hydrators, T316 SS.
1—Bird 32" x 50" horiz. cent., T316 SS.
2—Sperry 30" P. & F. filter presses, 19-9 st. st. (NI-RESIST).

HEAT EXCHANGERS—CONDENSERS

1—1960 sq. ft. T316 SS exchanger, ASME.
1—1450 sq. ft. T316 SS vert. condenser.
7—800 sq. ft. T316 SS vert. condensers.
5—400 sq. ft. T316 SS vert. condensers.
50—T316 SS condensers & exchangers: 735, 427, 300, 264, 250, 235, 200, 165, 150, 125, 110, 47, 30 sq. ft.
25—Copper & cupro-nickel exch. & cond.

CLOSING OUT

CRUSHING-GRINDING PLANT
MANCHESTER, CONN.

13—Abbe Eng. #1B pebble mills, 6' dia. x 8' long, buhrstone lined, 30 HP motors & drives.
2—Hardinge 7' x 36" conical mills.
1—Allis Chalmers 6' x 18' pebble mill.
1—Symons 3' short head cone crusher.
1—Buchanan 13" x 24" JAW CRUSHER.
3—Bucket elevators, up to 50' high.

SEND FOR CIRCULAR #360A

PERRY EQUIPMENT CORPORATION

1413-21 N. SIXTH ST. PHILADELPHIA 22, PA.

Phone POplar 3-3505

CIRCLE J ON READER SERVICE CARD

MONEL, NICKEL INCONEL, STAINLESS NON CORROSIVE EQUIPMENT

Zaremba Dbl. Effect INCONEL Evaporator; 430 sq. ft. surface

Bowen Stainless Steel Spray Dryer; Lab Model 30"x32"

Louisville MONEL Rotary Steam Tube Dryer; 54" x 35'

Struthers Wells STAINLESS Drum Dryers; 5'x4' and 5'x10'

Nickel Plated Dri Drums 4'x4'

2 MONEL Reactors, 2800 Gal. with Turbine Agts. Jktd. 175# ASME

NICKEL Clad Reactor; 7'x11'6"

Struthers Wells Type 316 S/S 2000 Gal. Jktd. Agtd. Reactors

STAINLESS Vac. Still 755 Gal.

Lancaster STAINLESS Lined Rot. Reactor; Jktd. 50"x17'4"

14 STAINLESS Pressure Tanks 700 Gal.

2 Stainless Lined 11,000 Gal. Pressure Tanks; 10'x18'7"

STAINLESS Dbl. Arm Vac. Mixer; 150 Gal.; cored Blades; 40 HP

2 Lehmann Amalgamators; S/S Lined; 32"x44"x36"; S/S Arms

Patterson-Kelley STAINLESS Twin Shell Blenders; 30-150 Cu. ft.

Oliver Dorrco NICKEL Rot. Vac. Filter; 6'x3'; NICKEL access.

Oliver Precoat Pressure Filter STAINLESS STEEL 5'3"x8'

Oliver Precoat Pressure Filter MONEL 3'x2'; 18 sq. ft. surface

Enzinger STAINLESS Pressure Filter; Vert.; 24 sq. ft.

Nutsche Type STAINLESS Filter 72"x24"; with Filter Plate

Sperry NICKEL and NI-RESIST Filter Presses; 12"x12"

Sparkler STAINLESS Filter; 560 Sq. Ft.

STAINLESS CENTRIFUGES from 12" to 60"; all types in Stock

2 Bird MONEL Screen Type 24" Centrifuges

Tolhurst Susp. 40" MONEL Centr.

2 Sharples MONEL Super Centr. M4P

Mikro STAINLESS Pulverizers No. 2

Fitzpatrick S/S Comminutators Model D 7½ HP; Model K 20 HP

Send for FIRST Facts

FIRST MACHINERY CORP.
209-289 TENTH ST.
BROOKLYN 15, N. Y.
STerling 8-4672

CIRCLE K ON READER SERVICE CARD

FOR "IMPOSSIBLE" BUDGETS

1—Downington 52 sq ft Nickel Shell and Tube Heat Exchanger

3—J. H. Day 100 gal Sigma Mixers. Cincinnatus size 6 Class 6

1—Pfaudler 150 gal unjacketed Glass Lined Kettle. 1 HP Agit.

2—Sweco 48" 3 Deck Screen. S.S. Screens. 1 HP Motor

1—66" x 35' Rotary Flame Dryer. Nickel lined Monel Lifters

1—Allis-Chalmers 10' x 200' Rotary Kiln. ¾" shell. Comp/equipped

2—Tolhurst 40" center slung rub. covered Perf. Bas. Centrifuge

2—Tolhurst 48" perf. Basket S.S. Centrifuges. Susp. type

For immediate quote, wire or phone collect—GA 1-1380

ME MACHINERY AND EQUIPMENT COMPANY
123 Townsend St. · San Francisco 7, California

CIRCLE L ON READER SERVICE CARD

AGITATOR—S/S w/10 HP xpl. proof 2 spd motor, 3" shaft x 6' long w/propeller—1 HP Lightnin' 1150 RPM

SCREENS—12" x 72" S/S Ajax—20 x 84, 20 x 96 Rotex—3 x 5, 3 x 10 Tyler Hummer

FEEDERS—S/S Vibrating 4½ x 24, 24 x 72 Syntron—Hardinge B Constant Weight

MILLS PULVERIZING—3 HP Sturtevant 00—10 HP Mikro 2 TH—30 HP Raymond—50 HP Mikro 3 TH w/Mikro Collector (unused)—100 HP Jeffrey 36 x 42—250 HP non-clog—450 HP Penna. SXT 14.

DRYERS, ROTARY—24" x 22', 3' x 24', 4' x 40', 5' x 50', 6' x 30', 7' x 58' all w/motor drives

DRYER, VACUUM SHELF—w/13 shelves 59" x 78", total area 356 sq. ft.

BRIQUETTING MACHINE—Komarek Greaves, 11/16 x 4-5/16 x ¼" dies w/feeder, motors, etc.

LAWLER COMPANY
Durham Ave. Liberty 9-0245 Metuchen, N. J.

CIRCLE M ON READER SERVICE CARD

Baker Perkins 150 gal 40 HP, 100 gal 50 HP. Both S.S. 2 arm jacketed vacuum hdr. tilt.

Aluminum Condenser 350 sq ft.

Aluminum Evaporator Calandria type, never used. 1300 sq feet tube area.

Continuous Stripping column 2 x 13 Steel.

Hydraulic Pumps & Meters.

Dryers Vacuum Shelf.

MACHINECRAFT CORPORATION
800 Wilson Ave. (East of Doremus)
Newark 5, N. J. MI 2-7634

CIRCLE P ON READER SERVICE CARD

PIPE

2,000,000 ft.	2"	3.50# to the foot
1,000,000 ft.	3"	7.70#
1,000,000 ft.	4"	10.98#
500,000 ft.	6"	19.80#
200,000 ft.	8⅝"	28#
400,000 ft.	10¾"	35#
75,000 ft.	12¾"	40#

All No. 1 Grade Plain End and Cleaned
INDIANA-OHIO PIPE CO.
P.O. Box 5412 Shepard Sta. Phone CL 3-5527
COLUMBUS 19, OHIO

CIRCLE Q ON READER SERVICE CARD

OVER 5,000 MACHINES IN STOCK
FOR EVERY INDUSTRY AND PURPOSE

- Wrappers
- Packaging machines
- Cartoning machines
- Fillers
- Labelers
- Filter presses
- Roller mills
- Mixers
- Pulverizers
- Grinders
- Dryers
- Sifters
- Cappers
- Tablet machines

TELL US YOUR REQUIREMENTS

Complete Details And Our Special Low Bargain Prices Available On Request

UNION STANDARD EQUIPMENT CO.
318-322 Lafayette St., New York 12, N. Y.
Phone: Canal 6-5333-4-5-6

CIRCLE N ON READER SERVICE CARD

BEST BUY

SPECIAL RAYMOND MILL

#1 Automatic Pulverizer Complete with Raymond 5'6" diameter Double Whizzer Separator.

Immediately Available

Wire or phone collect—GA 1-1380

ME MACHINERY AND EQUIPMENT CO.
123 Townsend St. · San Francisco 7, Calif.

CIRCLE R ON READER SERVICE CARD

COMPRESSORS
No better values at any price

74 CFM	1500 PSI	6¼-3¾-1⅝x7 CP. TCB3
100 CFM	150 PSI	6x7 Ing. ES-1
104 CFM	2500 PSI	6¼-4¼-11/16x9 IR-ES3
110 CFM	3000 PSI	Ing. GC 50BW
138 CFM	100 PSI	7x7, Ing. ES, CP & Joy
151 CFM	3000 PSI	13¾x12 Norwalk TRS-4T
288 CFM	100 PSI	9x9 Ing. Worth. CP & Penn
311 CFM	1500 PSI	10½-7⅛-3⅝x13 IR-ES3
351 CFM	350 PSI	11-5x11 CP TCB-2
401 SCFM	350 PSI	IR ESH2 (New)
465 CFM	100 PSI	12x11-IR-ES-1-Chic. P.T.
660 CFM	125 PSI	11¼-7x7 Joy Wn 102
686 CFM	100 PSI	14x13 Ing. ES-Chic. P.T.
877 CFM	125 PSI	17-10½x14 IR, XRB
1600 CFM	(actual)	100 PSI C300-300H Fuller (2)
1721 CFM	110 PSI	23-14x16 Ing. PRE2
2506 CFM	50 PSI	19-19x14 Pennsylvania DE-1

AMERICAN AIR COMPRESSOR CORP.
Chem. Road, North Bergen, N.J. UNion 5-1397

CIRCLE O ON READER SERVICE CARD

STAINLESS STEEL TANKS

Model J-1 24" x 45" 77 gal. 18,000 cu. in. 400 PSI 10 gauge type 304. Ship. wt. 250 lbs. Net 150. Value $300 BRAND NEW $99.50

Model F-1 same as J-1 except 81½" x 18". 16 gauge 1000 cu. in. . . $14.50. Carton of 8 . . $14.25

Terms 30 days net. FOB Baton Rouge, La.

ILLINOIS MFG. & SUPPLY CO.
1829 S. State, Chicago 16, Ill. Dept. 10 VI 2-6633

CIRCLE S ON READER SERVICE CARD

TO HELP YOU . . .
find equipment you need
"Searchlight" Advertising

Climb on the Bandwagon

BUY GELB

CHEMICAL PROCESS EQUIPMENT

8—Western States 40" type 316 SS suspended type centrifuges complete with perforated baskets, plows and 40 HP motors. Year Built 1953.
1—Acme type 316 SS Packed Column 2' x 31'9".
1—Struthers Wells SS 1000 gal. jacketed reactor, complete with impeller type agitator and drive, 50 psi jacket, 15 psi internal pressure. New.
1—Type 316 SS jacketed 1500 gal. Still complete with agitator, drive, condenser, column and all auxiliary equipment.

AUTOCLAVES, KETTLES AND REACTORS

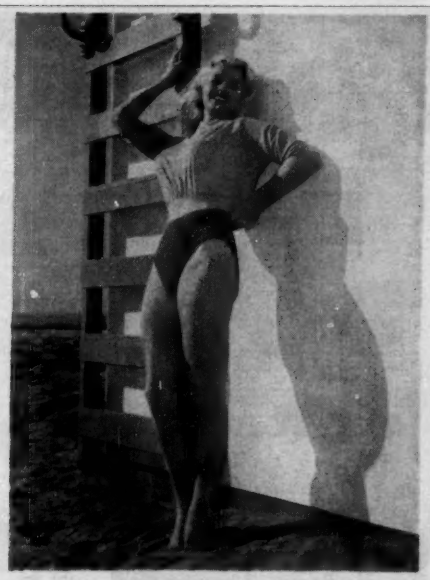
2—Pfaudler 200 gal. glass lined jacketed reactors, complete with anchor types agitators and drives
1—Struthers Wells type 316 SS jacketed reactor, 2000 gal. complete with agitator and drive.
1—Struthers Wells type 316 SS 400 gal., reactor with coils and turbine type agitator and drive, 250# coils
2—Pfaudler 300 gal. SS jacketed kettles, 76 psi jacket, 75 psi internal
1—Van Alst 250 gal. SS jacketed kettle complete with SS column and condenser
1—Pfaudler 200 gal. type 316 SS jacketed reactor, 75 psi jacket, 20 psi internal
2—Monel 2500 gal. jacketed autoclaves, 175# jacket, 175# internal
1—Autoclave Engineers type 316 SS autoclave, 1 gal. complete with motor, drive and coils, 1200# working pressure
2—Blaw Knox 600 gal. steel reactors, complete with double motion agitators and drives, 50# jacket, 50# internal
2—45,000 gal. type 316 SS vertical tanks
1—18,000 gal. aluminum storage tank

DRYERS

1—Allis Chalmers SS 6' x 50' rotary dryer, complete
10—Allis Chalmers rotary dryers, 6' x 50' and 7' x 60'
3—Link Belt steel roto louvre dryers, Model 207-10, 310-16, 604-20
1—Stokes Model 59DS steel rotary vacuum dryer, 5' x 30'
2—Louisville rotary dryers, 8' x 50', SS
1—Buflovak SS jacketed rotary vacuum dryer, 3' x 15'
3—Buflovak steel jacketed rotary dryers, 3' x 15', 5' x 20', 5' x 35'
1—Traylor 4' x 40' rotary dryer
1—Rotary dryer 6' x 36'
1—Western Precipitation Corp. SS pilot plant spray dryer, Type N-2
1—Bowen SS pilot plant spray dryer

FILTERS

3—Dorrco rubber covered filters, 5' x 2'
12—Sweetland #12 filters with 72 SS leaves
1—Niagara SS filter, Model 510-28
1—Oliver SS rotary pressure precoat filter, 5'3" x 8'
1—Oliver type 316 SS rotary vacuum filter, 4' x 5'
1—Oliver horizontal filter, 3'
1—GATX SS pilot plant filter, 2' x 6"
10—Shriver plate and frame filter presses, 12" to 42"
1—Shriver aluminum 30" x 30" P&F filter press, 30 chambers



THE GELB GIRL—JULY 1960

CENTRIFUGES

1—AT&M 48" SS suspended type centrifuge, complete with plow, motor and imperforate basket
1—Fletcher 48" center slung SS centrifuge, complete with perforate basket and motor
4—Tolhurst 40" center slung rubber covered centrifuges, with perforate baskets and motors
2—Fletcher 40" center slung rubber covered centrifuges with perforate baskets and motors

MIXERS

2—Sturtevant #7 dustite rotary batch blenders, NEW
15—Robinson type 304 SS horizontal blenders, 255 cu. ft.
1—Richmond Engineering type 316 SS 40 cu. ft. horiz. double ribbon blender
1—Baker Perkins Size 20, 2000 gal. double arm jacketed vacuum mixer with double naben blades
1—Baker Perkins Size 16, Type UUEM, 150 gal. jacketed double arm dispersion type mixer, complete with compression cover and 100 HP motor.
2—Baker Perkins 20 gal. SS jacketed vacuum double arm mixers
1—Banbury #1 mixer, chrome plate rotor, with 50 HP motor
1—Stokes SS granulating mixer, Model 21 J
1—Entoleter impact mill type PPM-27

MISCELLANEOUS

1—Vulcan SS bubble cap column, 4' x 25' plates
1—Badger type 316 SS bubble cap column, 42" dia. with 11 trays
1—Badger type 316 SS bubble cap column, 36" dia. with 8 trays
1—Struthers Wells type 316 SS heat exchanger, 330 sq. ft.
1—Condenser Service type 316 SS heat exchanger, 350 sq. ft.
3—Badger type 316 SS heat exchangers, 500 sq. ft. and 600 sq. ft.
10—Davis Engineering SS heat exchangers, 145 sq. ft., NEW
4—Davis Engineering Carp. 20, 125 sq. ft. heat exchangers, NEW
1—Downington type 316 SS heat exchanger, 750 sq. ft.
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2—Swenson type 316 SS vacuum crystallizer, 3'6" x 12', 2' x 12'
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1—Micro SS model 1SH Pulverizer, complete.

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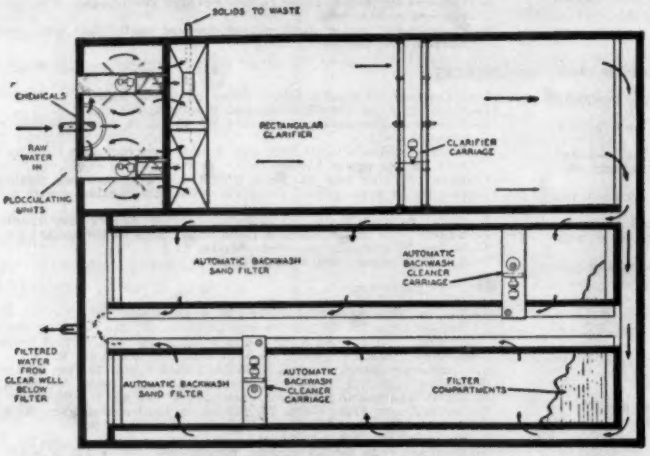

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SHEAR-FLOW

Shear-Flow's high shear action produces finer, faster blending, dispersing and homogenizing. The new Model RL Shear-Flow portable mixer represents a major advance in mixer design. The new Hi-Shear Head consists of two rotating impellers and two stationary stators enclosed in a cylindrical housing. The fine clearance between impellers and stators results in rapid shearing action and a high degree of turbulence, resulting in a more complete reduction of agglomerates within the mixture.

- Greatly reduces mixing time
- Uniform circulation—no vortex
- Emulsifies immiscible liquids
- Controllable flow pattern
- Chemically inert seals
- Handles viscous materials with ease
- No operating torque

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Close tolerances between impellers and stators promotes high shear for reduction and dispersion of material.

Adjustable deflector plate controls flow pattern for desired mixing action and air entrainment.

Three basic portable models for processing 1 to 250 gals. plus continuous mix units for high volume processing.

Write today for complete information on the Shear-Flow line of mixers.

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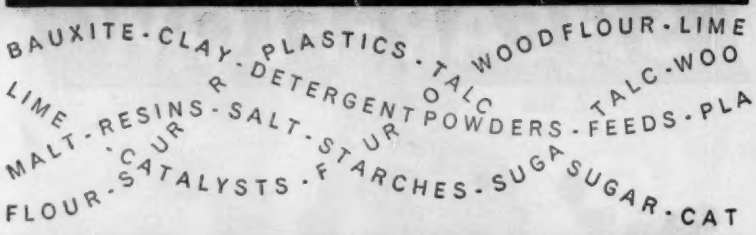
Windsor Locks, Conn.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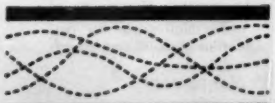
Typical savings (on an investment of $24,000) realized by a paper mill handling bulk starch are illustrated in this table.

	2,000,000 lbs.	3,000,000 lbs.
Volume (one type of starch)		
Annual Savings		
(a) *Bulk Price Differential—$.27/cwt*	$5,400	$8,100
(b) *Unloading, handling & losses—$.15/cwt*	3,000	4,500
TOTAL SAVINGS	$8,400	$12,600
Annual Costs		
(a) *Depreciation (over 15 years)*	$1,600	$1,600
(b) *Taxes (1% of investment)*	240	240
(c) *Repairs & maintenance (4%)*	960	960
(d) *Operation (labor, power, etc.)*	380	550
TOTAL COSTS	$3,180	$3,350
Summary		
Annual savings before Federal Inc. Taxes	$5,220	$9,250
Return before Federal Inc. Taxes	21.8%	38.5%
Net savings after Fed. Inc. Taxes (at 52%)	$2,505	$4,440
Return after Federal Inc. Taxes	10.4%	18.5%
Pay out time (after deprec. & Fed. Taxes)	9.6 yrs.	5.4 yrs.

Whether you require a complete Fluidization system or merely system components, Flo-Tronics can custom-build to your specifications or requirements. For an engineering evaluation of your material handling requirements—or simply a discussion of your needs with your own engineers, write or call Mr. William P. Edmunds, Dept. 100,



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Textile Technology in Chemical Engineering

The Final Test of a Filter Fabric

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A typical "acid test" may be found in the dyestuffs industry, where a dye intermediate is separated from a sulphuric and hydrochloric acid solution at 45 degrees C. This process, so corrosive that the filter press must be made of rubber-coated aluminum, successfully utilizes a spun dynel filter fabric designed for high chemical resistance, efficiency and durability.

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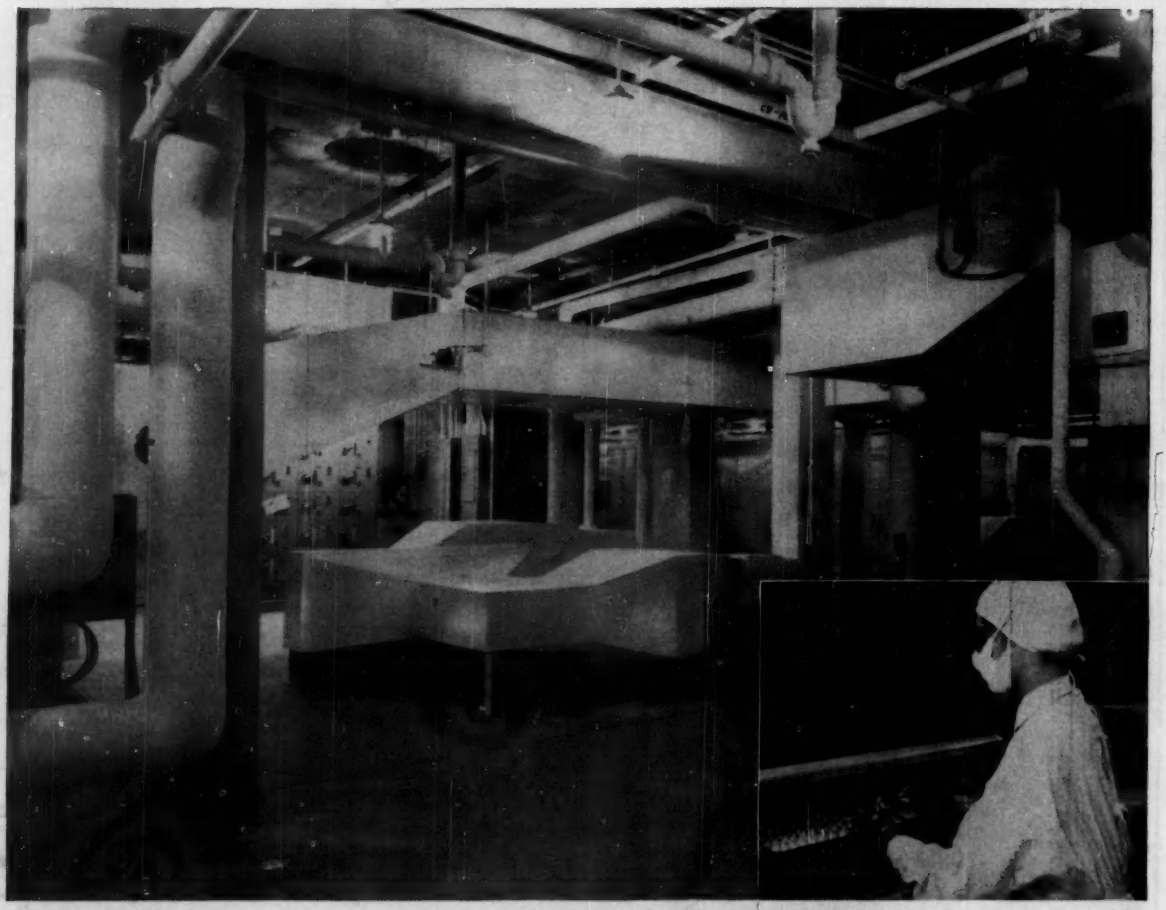

Styrofoam insulation on pipes and equipment maintains temperature and humidity for processing blood and pharmaceutical products.

STYROFOAM® prevents condensation . . . helps maintain exact temperatures!

In the production of pharmaceuticals, temperature and humidity are frequently critical . . . and sanitary requirements can't tolerate dripping pipes. That's why Styrofoam* was chosen to insulate pipes, ducts, even blowers in five separate cooling systems in a new Ortho Pharmaceutical Corporation installation at Raritan, New Jersey. Functions of the five systems range from maintaining efficient, low temperatures in cold storage rooms, to keeping one special processing room at exactly 80°F., with only 15% relative humidity.

Because Styrofoam resists penetration of water and water vapor, moisture does not get to the pipes to form an icing condition. This prevents condensation and dripping. In addition, moisture does not destroy the low "K" factor of Styrofoam, thus assuring permanently high insulating efficiency. And Styrofoam cannot rot nor deteriorate—has no food value to support plant or animal life.

The light weight of Styrofoam (only 2.4 ounces per board foot) helps designers by reducing the dead weight load on pipes—and speeds installation.

Dow supplies Styrofoam to the expert fabricators listed below, who shape it into standard pipe and vessel coverings and also make segments of special shape and thickness. Check with the nearest fabricator for full information. Or, write THE DOW CHEMICAL COMPANY, Midland, Michigan, Plastics Merchandising Department 1650AK7-11.

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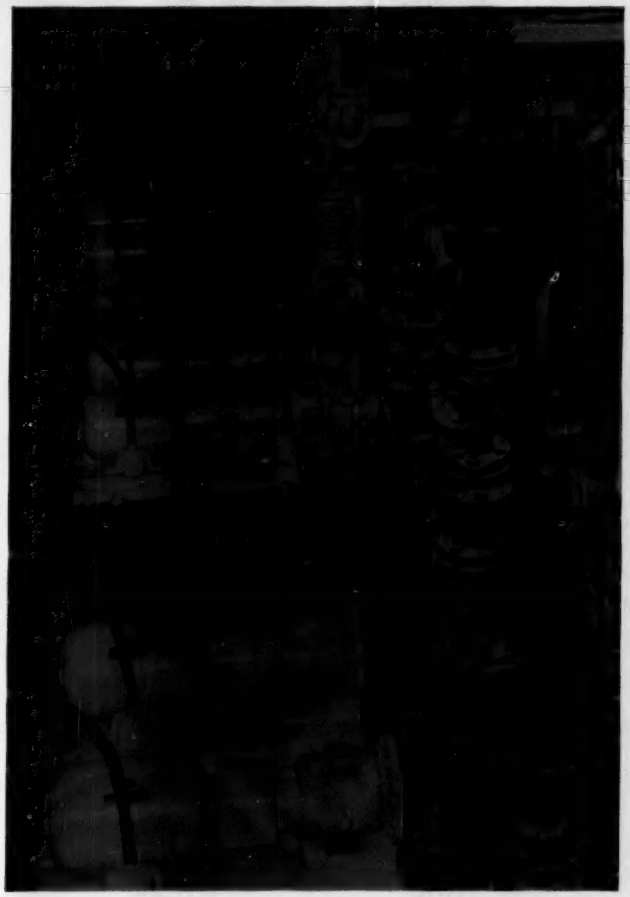

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Pumping parts are available in a variety of metal alloys, as well as plastic, to cover a wide range of corrosive applications. 1" to 8" discharge sizes with 10 to 3000 GPM capacities and heads up to 200' and higher.

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Wilfley Acid Pump

A. R. WILFLEY & SONS, INC.

GOOD MIXING is key to process control in butadiene-styrene reactors at new Dewey and Almy plant.

How they keep molecules from running amok in push-button latex plant

Look at the heart of this process, and you'll see LIGHTNIN Mixers working.

They're helping to make little molecules into big ones—20 million pounds of them a year—at the new Owensboro, Ky., plant of Dewey and Almy Chemical Division, W. R. Grace & Co.

Process control is exceptionally tight on the new plant's two parallel lines producing butadiene-styrene latices and PVAc emulsions for a host of uses. Either line can produce many types of emulsions to meet customers' special needs.

What mixers do

In each polymerization reactor, a turbine-type LIGHTNIN Mixer whips incoming monomers into an emulsion. Then, as the batch heats up to its catch point, the mixer keeps it turning over rapidly at uniform temperature throughout.

Once polymerization begins, heat control is critical; a rise of 10° F will double the reaction rate. Turbulence and flow from the big flat-blade turbines provide a high rate of heat transfer that helps to get excess heat out of the batch as rapidly as possible. As a result, heat-sensing devices in the reactor can feed accurate data back to the plant's automatic control center.

Ahead of the reactors, other LIGHTNIN Mixers swiftly combine monomers, emulsifiers, and catalysts to make up the reactor charge. At the far end of the line, LIGHTNIN Mixers also blend finished products, prior to shipment.

What's your mixing problem?

For your fluid-mixing operations, you can get LIGHTNIN Mixers as advanced as your own thinking. On complex mixing jobs, you can save precious hours of engineering by coming to MIXCO—and get the right answer, with mixing results unconditionally guaranteed.

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